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COUNTER CURRENT FLOW IN STEAM GENERATION

The Advantages of this Principle and Its Application to Economizer Practice

BY GEO. H. GIBSON

WHERE HEAT IS TO be transmitted from one fluid to another through an intervening partition, there are certain obvious advantages in having the 2 fluids move past a given point in opposite directions. That is, the heating fluid should enter upon the heat transmitting surface at the point where the heated fluid leaves, and the cooled heating fluid should leave the heat transmitting surface at the point where the still colder fluid to be heated enters.

By this means 2 objects are attained: First, it is possible to raise the heated fluid to a higher temperature and to cool the heating fluid to a lower temperature than would be possible if both fluids came in contact with the heating surface at the same point, and traveled in parallel paths to the outlet. For in the latter case, even with the most perfect heat transmission, an infinite extent of surface could only bring the 2 fluids to a common temperature; that is, the heating and heated fluids would leave the apparatus at equal temperatures.

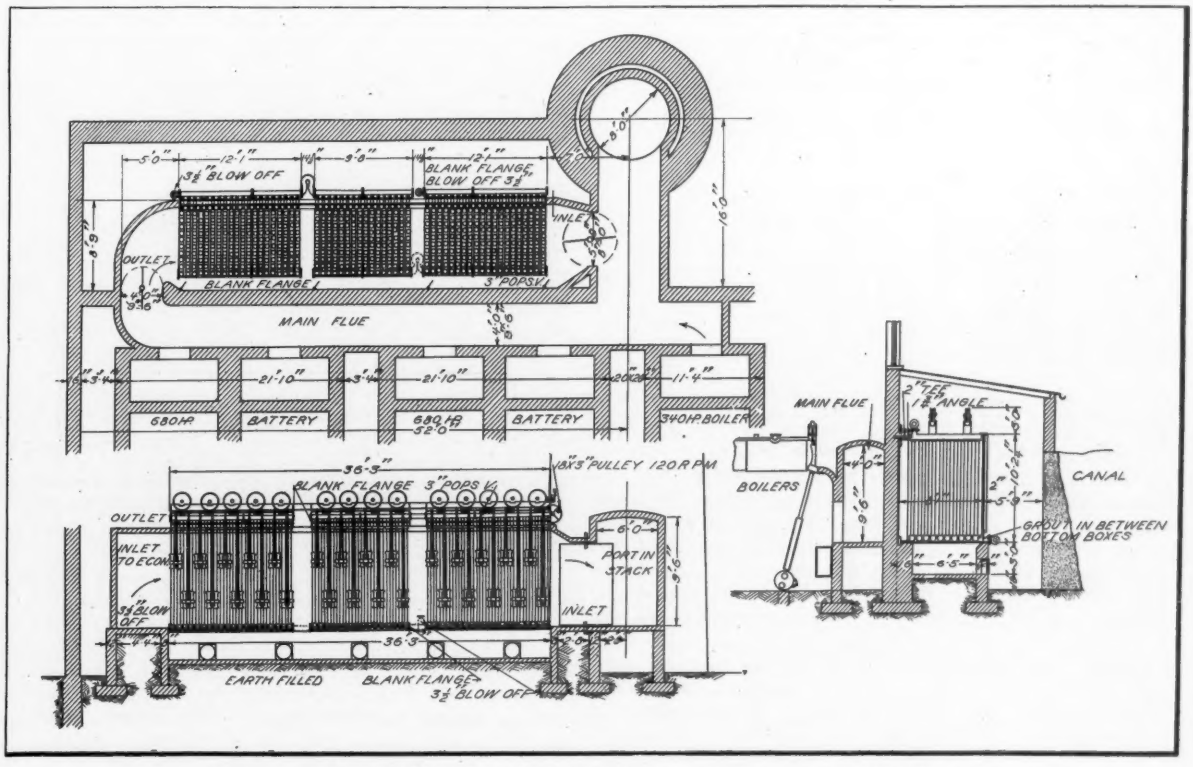


FIG. 4. SERIES-CROSS-FLOW ARRANGEMENT AS USED AT LONSDALE, R. I.

With counter current flow, however, it is possible for the heated fluid to leave the apparatus at a temperature higher than the temperature at which the heating fluid leaves. In fact, if the heat capacities

per unit time of the 2 currents are equal and sufficient surface is supplied, the heated fluid may leave the apparatus at a temperature nearly equal to that of the entering heating fluid, and the heating fluid may leave at a temperature nearly as low as that of the entering heated fluid, thus accomplishing an almost complete interchange from one fluid to the other of the heat of the heating fluid above the entering temperature of the heated fluid.

The second important advantage of the counter current method of operation is that a greater average temperature difference is maintained and therefore more heat is transmitted per unit of heating surface. The statement of just what this difference is involves some statement or assumption regarding the influence of temperature difference upon heat transmission. The conclusion reached by most investigators has been that the flow of heat between fluids across a heat transmitting surface is in proportion to the difference between the temperatures of the fluids on the 2 sides of the partition.

If the range of temperatures is great, this probably needs to be modified, in the case of gases, to accord with certain deductions from the kinetic theory of

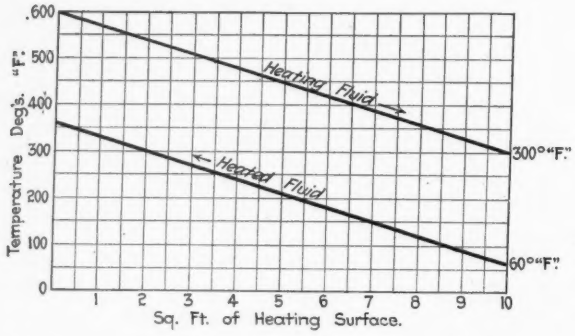


FIG. 1. TEMPERATURE RELATIONS IN COUNTER-CURRENT HEATING APPARATUS, WITH HEAT CAPACITIES OF CURRENTS EQUAL; 9600 B.T.U. TRANSFERRED PER HOUR BY 10 SQ. FT.

gases, which indicate that the transmission of heat per degree difference of temperature should be greater at high temperatures than at low temperatures.

Rapidity of Heat Transfer

WITHOUT going into the more complicated theory of the subject, the effect upon heat transmission of the parallel and counter flow arrangement is easily illustrated by diagrams. A very simple case for illustrative purposes is that where the heat absorbing capacities per minute of the 2 streams of fluid are the same; that is, where a decrease of 1 deg. F. in the temperature of the heating fluid corresponds to an increase of 1 deg. F. in the temperatures of the heated fluid.

With counter current flow, if we plot temperatures as ordinates and square feet of heating surface as abscissas, the temperature curve of the heating fluid will be parallel to that of the heated fluid, as shown in Fig. 1, and the difference of temperature producing flow of heat across the partition will at every point be equal to the initial difference of temperature, which is also equal to the final difference of temperature. Then if, for example, the rate of heat transmission in a particular case is 4 B.t.u. per sq. ft. per hour for each degree difference of temperature, and the initial difference of temperature is say 240 deg., the amount of surface required to transmit 9600 B.t.u. in one hour is 10 sq. ft.

The corresponding situation for parallel flow is illustrated in Fig. 2. In this case each degree fall in temperature of the heating fluid is accompanied as before by an equal rise in the temperature of the heated fluid; but the result of a fall in the temperature of heating fluid and a rise in the temperature of the heated fluid, since both liquids are traveling in the same direction, is to reduce the temperature difference between the 2 fluids and, therefore, to reduce the rate of heat transfer across the partition. As we proceed

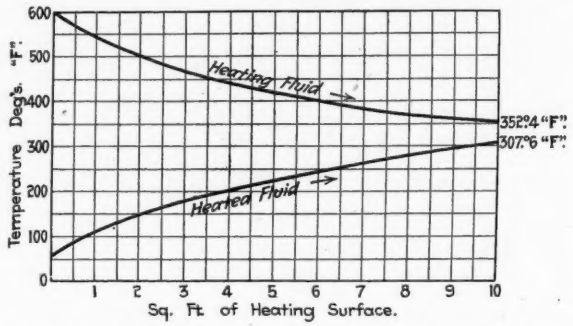


FIG. 2. TEMPERATURE RELATIONS IN PARALLEL FLOW HEATING APPARATUS; 7910 B.T.U. TRANSFERRED PER HOUR BY 10 SQ. FT.

along the surface, less and less heat is, therefore, transmitted per square foot of surface; or, conversely, more and more surface is required to transmit a given number of heat units.

It is easily shown that these 2 fluids are logarithmic curves and that they will not touch until infinity is reached; that is, the 2 fluids cannot be brought to the same temperature without the use of an infinite amount of surface.

Action of the Steam Boiler

THE steam boiler is obviously neither a counter current nor a parallel flow machine, since the temperatures of the water and of the steam are practically the same in all parts of the boiler. As regards

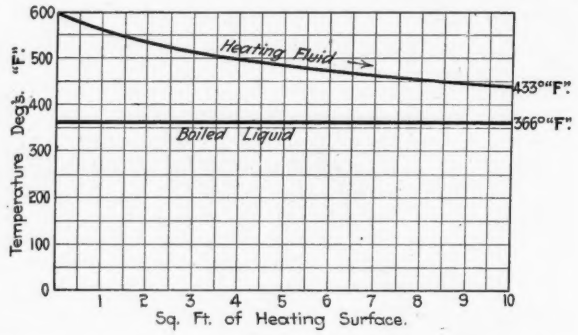


FIG. 3. HEAT TRANSFERRED TO WATER IN BOILER AT 150 LB. GAGE; 5340 B.T.U. PER HOUR FOR 10 SQ. FT.

the amount of surface required to transmit heat, however, it bears many resemblances to the parallel flow machine, as will be evident from an inspection of Fig. 3.

In order that the temperature of the gases of combustion may be reduced near to the temperature of

the water and steam in the boiler, an increased amount of heating surface will be required, and as a matter of commercial practice it is found that after the temperature of the gases drops to around 250 deg. above the temperature of the water and steam within the boiler, the annual charges upon any additional heating surface more than counterbalance the value of the heat absorbed by such additional surface.

This, however, implies a rather high temperature of the escaping gases. For instance, at a boiler pressure of 200 lb. gage the temperature of the steam is 388 deg. F. Adding 250 deg. to this gives us a temperature of 638 deg. for the gases passing to the stack. If we assume a heating value for the coal of 15,000 heat units per lb. and that 24 lb. of air are supplied to burn one pound of coal, also that the temperature of the external atmosphere is 60 deg. F., it may easily be shown that 23 per cent of the heating value of the coal would be lost in the gases leaving the boiler.

Consideration of this material loss, which in many cases is still greater, due to greater excess of air or due to higher temperature of the escaping gases, early led to the invention and use of the economizer, in which the gases are progressively cooled and the water is progressively heated, so that from a thermal standpoint this apparatus is peculiarly adaptable to the counter-current method of operation.

Cross Flow in the Economizer

PRACTICAL considerations, however, early led to the adoption of a method of water circulation in economizers that can be described neither as counter-current nor parallel flow, but rather as cross flow. That is, the vertical pipes of the economizer are arranged in sections of 6, 8, 12 or more pipes pressed into top and bottom boxes, and the sections are set side by side to form economizers of 20, 40 or more sections, the gases being passed through this group of pipes endwise, as we might say, and the water being fed into a branch pipe communicating directly with each of the bottom boxes, whence it flows upwards through all the pipes in parallel and into a branch pipe communicating with each of the top boxes.

In passing, an exception to this practice should be noted in that, where the water is initially below 100 deg. F. in temperature, it is customary to pass it first through a small number of pipes at the end of the economizer where the hot gases enter before passing it through the remainder of the pipes in the manner just described. This, however, is in order to avoid the effects of condensation on the exterior of the pipes, and not for thermal reasons.

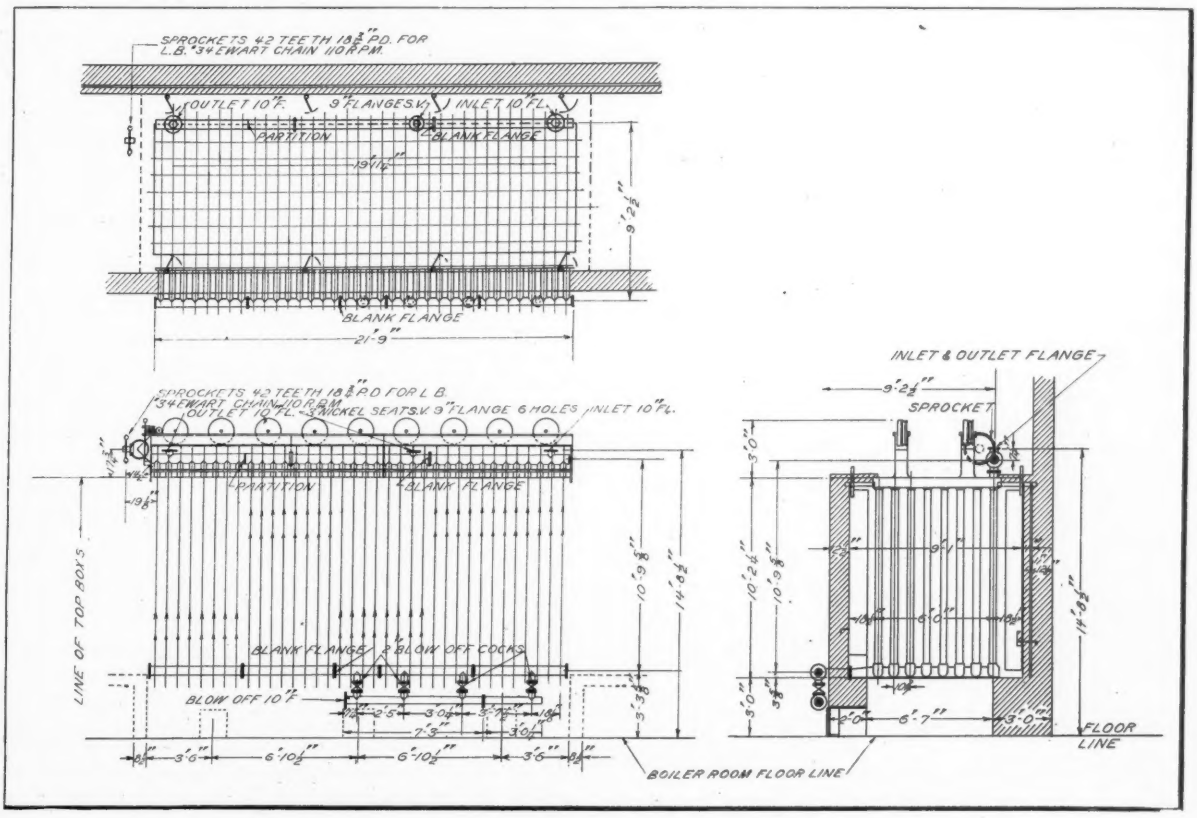


FIG. 5. COUNTER-CURRENT METHOD AS APPLIED AT THE STANLEY WORKS INSTALLATION

In passing through a large flue of any length, the gases of combustion become stratified, the hotter gases rising to the top and the colder gases traveling along the bottom of the duct.

When the gases strike the first row of economizer pipes, the cooler gases at the bottom of the flue come in contact with the cold water which is just leaving the bottom box, while the hot gases at the top of the chamber surround the upper ends of the pipes

Strange to say, however, the cross flow method of feeding the economizer gives results that are little, if any, inferior to those of counter-flow, and in some cases where tests have been made, there has been no perceivable difference at all. This comes about, however, from certain conditions which may be described as follows: In passing through a large flue of any

which are filled with the hottest water about to enter the top boxes.

As the gases progress through the economizer, their temperatures become less and less, both at the top and at the bottom, but as all the pipes of the economizer are in parallel as regards the flow of water, the inlet and outlet being at opposite corners, and as the first pipes receive the most heat from the gases, the first sections, containing hotter and lighter water, tend to circulate fastest, and the last pipes where the gases leave, circulate slowest, so that the rise in temperature in the water passing through each tube is not far from equal.

Some years ago, comparative tests of a circulating economizer and a Green Economizer arranged on the ordinary cross flow plan were made by the chief engineers of 4 of the leading boiler inspection and insurance companies of Great Britain, with results summarized by Lavington E. Fletcher, Member of the Institute of Civil Engineers and Chief Engineer of the Manchester Steam Users Association, in the following words: "The figures obtained during the tests do not show any practical advantage in the continuous current system over the ordinary system."

Moreover, to counterbalance any anticipated advantage in counter-current circulation through the economizer, it will at once be seen that an economizer arranged in the ordinary manner for cross flow is much more easily cleaned than is the circulating economizer, for all that it is necessary to do in order to wash out the pipes is to open a blowoff valve in the bottom access pipe, knock in the caps over the tops of the separate pipes, and then flush them down with a hose. A circulating economizer, on the other hand, must be provided with an independent blowout at the bottom of each loop or inverted U, formed by each pair of sections.

Some years ago, an improved construction to avoid this difficulty was patented by the Green Fuel Economizer Co., as shown in Fig. 4. In this construction, the branch pipes are replaced by what are called manifold headers, which contain valves between each alternate pair of sections, and by closing the valves in both top and bottom manifolds, the water is compelled to circulate according to the counter-current principle, while by opening the valves the pipes may be flushed out through the blowoff in the ordinary way, or the economizer can be operated by the ordinary cross-flow system.

The use of these internal valves apparently involved enough complication to have effectually discouraged their use. But, with the higher drafts that are now available from better chimneys and fans, it is possible to modify the method of installing economizers so as to secure higher velocities of the gases of combustion over the heating surfaces, which, as has been shown by recent investigations, increases the rate of heat transmission and also has the effect of preventing the stratification of the gases before referred to. Under these conditions, therefore, countercurrent operation may in some cases become an advantage.

At the same time, it is probably not necessary to go to minute subdivisions of the heating surface, but a large economizer can instead be divided into 3 or 4 groups, through each of which the water can circulate in the ordinary manner, while the groups are arranged in series. Figure 4 shows an installation of a 560-pipe Green economizer at the plant of the Lonsdale Company, Lonsdale, R. I., arranged in this manner. As will be seen, the gases enter the economizer and pass to the stack through the dampers at the right, while the water enters the bottom access pipe of the division of the economizer at the right, consisting of 20 sections of 10 pipes each, passing up through these pipes in parallel to the top access pipe, from which it enters the top access pipe of the next division, consisting of 16 sections, going down through these to the bottom access pipe, whence it enters through an expansion elbow to the bottom branch pipe of the final group of 20 sections.

Readings made when the boilers were operating at about nominal full load, show that the water was entering the economizer at a temperature of 138 deg. F. and the boilers at a temperature of 234 deg. F., a rise of 96 deg., amounting to a saving approximately 10 per cent of fuel, or about 1000 tons of coal a year, if the boilers are operated at full load 10 hours a day.

At the same time, the temperature of the gases was observed to be 530 deg. at the entrance to the economizer and 325 deg. F. at the entrance to the stack, a drop of 205 deg. F., or slightly more than twice as great as the rise in temperature of the water, indicating that the weight of the air used to burn the fuel in this plant is a little more than 2 times the weight of the water evaporated, or roughly, that there are about 25 lb. of gases per pound of fuel, with ordinary coal.

With the economizer arranged in this manner, it is evident that the gases could be cooled considerably lower, the temperature of the entering water forming the lower limit. In fact, a calculation based on setting off the value of the heat regained against the annual charges on additional economizer surface would show that with coal costing $3 a ton, the gases might profitably have been brought down to a temperature 80 deg. above the temperature of the entering water, which would be accomplished by a rise in the temperature of the feed water of 156 deg., corresponding to a coal saving of about 1500 tons a year. A flue gas temperature of only 218 deg., however, might seriously interfere with the chimney draft, and so was not attempted, although with mechanical draft it could profitably be approached, especially as the colder gases could be handled more efficiently and by a smaller fan.

An installation at the Stanley Works, in which the countercurrent method has been applied to an even greater extent, is shown in Fig. 5. As will be seen, this economizer consists of 576 pipes, but is only 8 pipes wide. It is also broken up into a greater number of passes. There are two main groups, as will be noticed, each of which is broken up into 4 passes. The method of interconnecting the branch pipes will be easily understood, the continuity of the branch pipe being broken between passes by means of blank flanges inserted between the regular flanges in the branch pipe. With this equipment the following temperatures were noted: Gases entering, 670 deg. F.; gases leaving, 360 deg. F.; water entering, 156 deg. F.; water leaving, 262 deg. F. The rise in temperature of water is therefore 106 deg. and the fall in temperature of the gases is 310 deg., indicating a smaller weight of gases per pound of coal than in the former case; in fact, the plant must have been operating very economically at the time these readings were taken. In any case, the economizer is reducing the coal bill by fully 11 per cent.

IT IS WELL to have visions of a better life than that of every day, but it is the life of every day from which elements of a better life must come.—Maeterlinck.

PURCHASING THE BOILER

Statement of Requirements and What Can Be Expected From Boilers

By Hubert E. Collins

IN the majority of instances the manager or owners study every other condition in the production of the factory or works, but leave the power plant alone, is the opinion of Mr. Myers stated in his article in a recent issue of the Engineering Magazine, which calls to mind facts which are the explanation of many plant failures.

The boiler room is the most vital part of the plant which up to 10 years ago was not given as much thought as the engine room. A close study has shown much of the plant troubles existing here through lack of knowledge of design or operation. Mr. Myers has ably pointed out much of this trouble.

Loosely drawn specifications are the inception of the trouble.

Poorly drawn for want of proper knowledge of requirements.

Requirements of manufacture and of economical operation.

A knowledge of these will not allow unscrupulous or irresponsible manufacturers to supplant the reliable ones in the first proposals. Just what this means will be shown in a set of specifications and their analysis which will be given in an article in a subsequent issue.

Before specifying the boiler we must first consider the general requirements of the plant.

Proportioning Steam Boilers

ONLY a certain amount of heat units can be transferred through each square foot of heating surface in a boiler when the highest economy is being realized.

Henry C. Meyer, Jr., in his book on Steam Power Plants, says: "By increasing the supply of heat a greater amount is transmitted and consequently a greater amount of water is evaporated by each sq. ft. of heating surface, but with the increase, the same percentage of the heat generated is not utilized. The reason is that after a certain rate of evaporation is reached, the maximum capacity of the metal in the boiler plates to transmit the heat is more nearly reached, and hence, a larger percentage of the heat of the fuel passes up the chimney. In other words, it is possible to evaporate a certain amount, say 3 lb., of water per square foot of heating surface in a given time and to utilize a certain percentage, say 80 per cent, of the heat in the fuel, 20 per cent going to waste. It is also possible to burn more coal and evaporate say 5 lb. of water per square foot of heating surface in the same time, but when doing so a greater percentage, perhaps 30 per cent of the heat of the fuel is lost. The selection of the proper amount of heating surface for a steam boiler is, therefore, a very important matter."

It has been found that the best efficiency is obtained with most boilers when evaporating about 3 lb. of water per square foot of heating surface per hour, from a feed temperature of 212 deg. F. into steam at atmospheric pressure. This is equivalent to allowing nearly 12 sq. ft. of heating surface per boiler horsepower. The boiler manufacturer's association has adopted the standard of 10 sq. ft. of heating surface to a horsepower in horizontal tubular boilers.

In specifying a boiler to be purchased, it is not sufficient merely to specify that the boiler is to be a certain horsepower, but the amount of heating surface which is to be supplied for the given horsepower is what should be specified. If horsepower only is specified, it allows the manufacturer to place his own estimate upon the amount of heating surface which is required. They may furnish boilers of the required horsepower, but in order to secure the results in one case will require the burning of a great deal more fuel in the other. The evaporation per sq. ft. of heating surface will be greater in one case than in the other in order to secure the required horsepower and as has been stated, the efficiency of the boiler decreases as the rate of evaporation increases above a certain point.

The type of boiler is also another consideration on which many purchasers go astray. For several years it was believed that the water tube boiler was far more efficient than the fire tube boiler. Subsequent experience and careful tests conducted by the A. S. M. E. have established the fact that there is nothing to choose between these 2 types of boilers so far as efficiency is concerned. The principal thing to look out for is the proper proportion of heating and grate surface per horsepower. The water tube boiler will steam quicker and at the same time will lose steam just as quick. The water-tube boiler is freer from disastrous explosions which wreck property, but just as much damage seems to result to the operators from bursting tubes as from the accidents which occur with the fire tube boiler.

If a new plant is to be installed, the first step to be considered is the proper division of heating surface into units of proper size. Take for example a boiler plant of 600 hp. is required. $600 \times 30 = 18{,}000$ lb. of water to be evaporated per hour.

We agree that 3 lb. of water per square foot of heating surface is most efficient and with this allotment of work to heating surface it is possible to get 33 1/3 per cent over-load capacity continuously. Then let us consider the best number of units to have in this plant.

$18{,}000 \div 3 = 6{,}000$ sq. ft. of heating surface required for whole plant.

Let us divide this into 3 units and see what we get.

$6{,}000 \div 3 = 2{,}000$ sq. ft. of heating surface to each unit.

The normal capacity of each unit will be $2000 \times 3 = 6000$ lb. evaporation per hour. $6000 \times 1.33\frac{1}{3} = 8000$ lb. evaporation per hour at $33\frac{1}{3}$ per cent overload. Now, if for any reason we need to cut out one boiler, we could evaporate with 2 boilers, $8000 \times 2 = 16{,}000$ lb. of water per hour which would be short of the full plant capacity.

Now let us divide our plant into 4 units and see what we get.

$6000 \div 4 = 1500$ sq. ft. of heating surface to each unit.

The normal capacity of each unit will be $1500 \times 3 = 4500$ lb. water per hour. $4500 \times 1.33\frac{1}{3} = 6000$ lb. evaporation per hour at $33\frac{1}{3}$ per cent overload. Now if we need to lay up one of these units, we can evaporate $6000 \times 3 = 18{,}000$ lb. of water per hour which would be the required capacity. Therefore, it would be best to divide this plant into 4 units.

Grate Surface

NEXT to insufficient heating surface, comes insufficient or improperly designed grate area as the source of trouble with boiler installations.

Evaporation is one thing, but before this takes place, heat must be generated. A study must be made of the kind of fuel to be used, the proper proportion of grate area to the fuel, and the draft.

Ample grate area is at all times essential for economy and continuous operation. It is especially so where boilers are to be forced at any time. Of course, proper draft is also essential. First find out the cost and evaporating qualities of fuel available in the neighborhood of the proposed plant. Then construct the boiler to suit the cheapest fuel (price and evaporative power considered). More boiler plant failures result from neglect of this one point than from any other one cause. Take the low grade anthracite coals which in the Metropolitan District is the principal fuel, it is not possible (without mechanical draft) to burn more than a limited amount of this fuel, as the particles on the grate pack so closely together that the air cannot get through in sufficient quantity to cause rapid combustion. Again, a fuel high in ash and sulphur is limited in the rate at which it can be burned. Of course, if a limited amount of fuel only can be burned on a grate, the maximum grate area should be installed. Low grade fuels should call for the largest grate area proportional to heating surface in the first place. If large grates have been installed for low grade fuel and it is desired to use higher grade fuels at any time, the proper size grate for economy can be made by bricking off some of it. Too large grates for high grade fuel would result in lower rate of combustion which would not consume the gases.

Of the 2 faults in grate construction, to have too large a grate is most desirable.

If one knows the amount of fuel that should be burned and then the amount that must be burned per square foot of grate area, then the amount of grate surface can be determined.

The accompanying table of relative values of steam coals is taken from Meyer's Steam Power Plants. He says, "the relative evaporative power of the better grades of a number of different coals is shown in the table, Pocahontas coal being placed at 100 . These figures are approximate and should be used with some caution. The relative evaporation for the different coals shows what might be expected from the better grades of each kind of coal mentioned when fired by a good fireman under ordinary every day conditions. The variation from these figures which might result from a difference in the quality of the coal from the same mine would be greatest with the Western coals, less with the Pennsylvania bituminous, and least with the semi-bituminous group. The anthracite, particularly the smaller sizes might vary considerably on account of an abnormal amount of impurities present in the coal. The figures given in the table can be exceeded when all conditions are favorable."

RELATIVE VALUES OF STEAM COALS

Kind of Coal	Relative Evaporative Power	Pounds of water that 1 lb. of coal will evaporate into steam from 212 Deg. F. Ordinary conditions	Pounds of coal per sq. ft. of grate per hour.	Ratio of heating to grate area.
1—Pocahontas W. Va.,.....	100.	9.5	15	45
2—Younghiogheny, Pa.....	92.5	8.7	17	48
3—Hocking Valley, O.....	80.	7.6	18	45
4—Big Muddy, Ill.....	80.	7.6	20	50
5—Mt. Olive, Ill.....	67.5	6.4	20	45
6—Lackawana, Pa., broken....	87.	8.5	15	35
7—Lackawana, Pa., No. 1B....	73.	7.5	13	32
8—Lackawana, Pa., Rice.....	63.	7.	12	30

No. 1 Semi-bituminous.
No. 2, 3, 4, 5 Bituminous.
No. 6, 7, 8 Anthracite.

This table shows that the amount of coal that should be burned per square foot of grate area per hour (rate of combustion) and the proportion of heating surface per square foot of grate to be allowed under ordinary conditions.

The writer ventures to state that 75 per cent of all boilers installed in the Metropolitan district have a ratio of 45 or over, and right there lies the trouble with many plants.

DOUBLING BOILER CAPACITY

REMARKABLE success has been achieved in increasing the capacity of existing boiler installations with small increase in investment. Formerly when the existing boiler equipment no longer supplied the demands for steam, the only remedy was to buy more boilers. This procedure resulted in the establishment of a pretty definite value for a boiler horsepower.

The advent of the modern stokers, operating on forced draft, has, however, completely changed this viewpoint. No longer is a load of 150 per cent rating considered abnormal for a good boiler, as 200 per cent and even more has been reached in some cases. It is evident that this tendency is leading to entirely different methods of increasing the capacity of power houses. Instead of doubling the number of boilers when the load demands it, modern practice favors doubling the capacity of the boilers already installed by equipping them with automatic stokers and forced draft. A case in point is that of the Bridgeport Plant of the New York, New Haven & Hartford R. R.

This station was equipped with 3 500-hp., and 2 350-hp. Babcock and Wilcox boilers with hand firing and induced draft. A shortage of steam made it necessary to increase the capacity of this station to the extent of 500-hp. The problem resolved itself into 2 possibilities, either to buy a new 500-hp.. boiler or to double the capacity of one of those already in service. After carefully considering the latter it was decided to be much the cheaper method and accordingly one boiler was equipped with a Taylor gravity underfeed stoker. With this stoker in use there was no difficulty in running at 200 per cent of rating and thus to accomplish as much with this boiler as with 2 of the same size hand fired and with natural draft.

Shortly after the installation of this stoker, a situation arose due to the disabling of one of the main engines which greatly increased the load on the other engines, and likewise the station water rate. At the same time the induced draft fan engine met with an accident, and for some time during the period of peak load the station was dependent on the one stoker fired boiler with such assistance as could be rendered by the hand fired boilers operating with the draft of a short stack. The stoker was operated at the maximum speed of which its engine was capable and in spite of the handicap managed to maintain steam pressure during the entire night until relieved by the completion of repairs on the fan engine.

TRANSPORTATION ON THE LITTLE KANAWHA

By Lewis C. Allen

THE internal combustion engine has been made to serve in various ways to facilitate travel and transport freight, and notwithstanding that the service in most cases is severe, and the operator unskilled, this type of motive power is carving a name for itself along side of its older sister, steam.

In the Allegheny Mountains, immense batteaus of lumber are caught after the journey through the rapids of the mountain rivers, and towed to the unloading dock by diminutive open yawls, equipped with single cylinder gasoline engines. The whole boat outfit, in the majority of cases, costs less than $125.

Gasoline hoisting engines load and unload lumber, and skid and pile lumber in the woods better than steam

FIG. 1. THE LEONE ON THE LITTLE KANAWAHA RIVER

driven hoists, especially on the mountain side where the water is scarce and fuel is hard to deliver. The same type of hoisting engines are used in hauling incline cars up the mountains, and in several places up the steep bank of a river, from the steamboat landing to a warehouse out of the reach of high water. Even the coal mines now use these engines for operating their fans and pumping water where the plants are located long distances from the central power plant.

The gasoline engine has come to be the favorite pumping engine, with many of the eastern roads, especially in the mountains where the work is severe, because the cost of operation is so much less.

As an example of the use of internal combustion engines by railroads, the Little Kanawha Railroad, of West Virginia, is perhaps the most interesting. The Little Kanawha Railroad makes use of a gasoline packet boat to carry its passengers from the present terminus of its road, Owensport, West Virginia, to the head waters of navigation on the Little Kanawha River, at Creston, West Virginia, a distance of 22 miles. This gasoline-driven boat, called the Leone, has been in service over 10 years, and during that time has made 2 daily trips with as much regularity in her schedule as could be expected from a steam boat. The Leone brings passengers, express and freight from Creston to Owensport and transfers them to the railroad; the railroad brings them to Parkersburg, West Virginia, and after turning around on a Y, which extends out over the river in such a way that over half of the rear coach is supported by the branches of 2 large maple trees, the train proceeds on its way down over the bank of the river on to a large scow. This scow used to be towed across the river to enable the train to climb the bank on the other side and run into a station in the town of Parkersburg, West Virginia.

But as the scow became old and was condemned by the United States authorities, it is now used as a landing

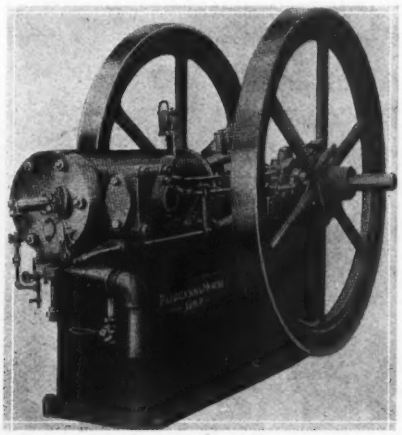


FIG. 2. THE LEONE'S ENGINE

dock and the passengers are transferred to a steamboat, which takes them about a mile down the river and lands them at the city wharf. If this road only had an air ship in connection with its other modes of transportation, a passenger would make use of all the common methods of transportation in less than 60 miles of travel. As it

FIG. 3. A DEAD STOP AND TRESTLE OF GROWING MAPLE TREES

is, a passenger gets the sensation of being in an air ship while the train is suspended in the branches of the trees out over the river.

The success of the Leone as a common carrier, has caused a fleet of sister boats to be placed in commission along the various pool ways of the river. These boats tow lumber and carry oil well supplies and general freight through the swiftest rapids and over shoals that would baffle a steam driven boat. They have taken work of the steam boats away to such an extent in this locality that all the steam boats but one have abandoned the trade.

NEW DEVELOPMENT IN STEAM TURBINES

COMBINING the impulse and reaction turbine principles, John H. Van Deventer, of the Buffalo Forge Co., has invented a new type of steam turbine which is called the Spiro, and is now, after a long series of successful experiments and tests, placed on the market.

As it is of small size and in horsepower ranges from the smallest up to several hundred, it fills a gap which

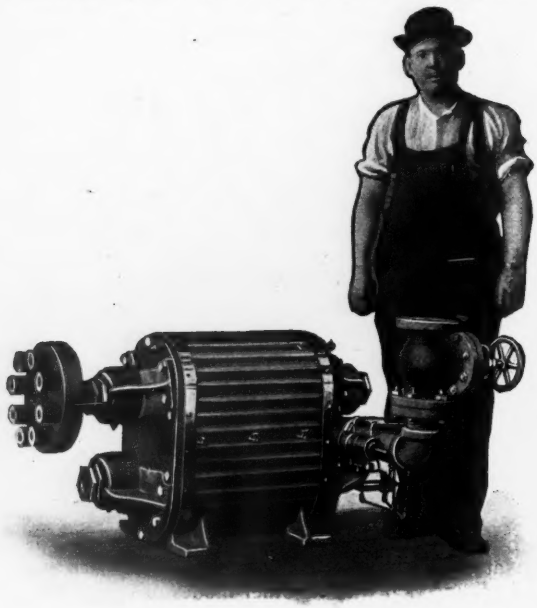


FIG. 1. 185-HP. SPIRO COMPARED IN SIZE WITH MAN

has long been the goal of manufacturers of existing steam turbines. The principle of its design and operation is seen at a glance from the 2 runners with the herringbone teeth. The steam impinges in the central pocket formed by the juncture of the teeth.

Three years of development and perfection already lies behind it. The salient points about its strength, durability and economy are therefore matters that have been settled to the satisfaction of the most conservative. It is pronounced by many eminent engineers to be an important step forward in the art of steam engineering, as any turbine invention necessarily must be termed which brings about a steam economy ranging from 20 to 50 per cent better than the best of existing standards.

The construction of the turbine is extremely simple. It consists essentially of 5 parts, the case, 2 heads with bearings, and 2 rotors. These rotors consist simply of helical gears, cut by special machinery, without any loose or inserted blades. The steam action within the pockets formed by these spiral gear teeth is theoretically perfect, making full use of the impact of the fluid due to its velocity, and avoiding the leakage usually found in turbines, which is the chief cause of their lack of mechanical efficiency.

The first impression of the Spiro is its extremely small size for a given power. The photograph showing the 186-hp. turbine illustrates this forcibly. This particular outfit has been in use for the last 3 years as a motive power in driving fans, gas scrubbers and other apparatus requiring a running test. It has not been apart, or had a single adjustment made upon it since its installation. The stated power of this outfit, namely 186 hp., was developed under 100 lb. initial pressure. It has been decided to base the rating of all Spiro turbines on this pressure, in opposition to common practice among turbine manufacturers who use 150 lb. initial pressure as a basis. This appears to be a sensible move as 100 lb. unquestionably comes closer than 150 lb. to representing the initial pressure under which small size turbines as a rule are required to run. The latter rating, with corresponding water rates, have always been somewhat misleading.

The Spiro is at present manufactured in sizes from 1 to 50 hp., noncondensing; and patterns are being rapidly completed for an extension of sizes up to 300 hp.

It is found that in many cases where an engineer would be able to make good use of a small turbine for

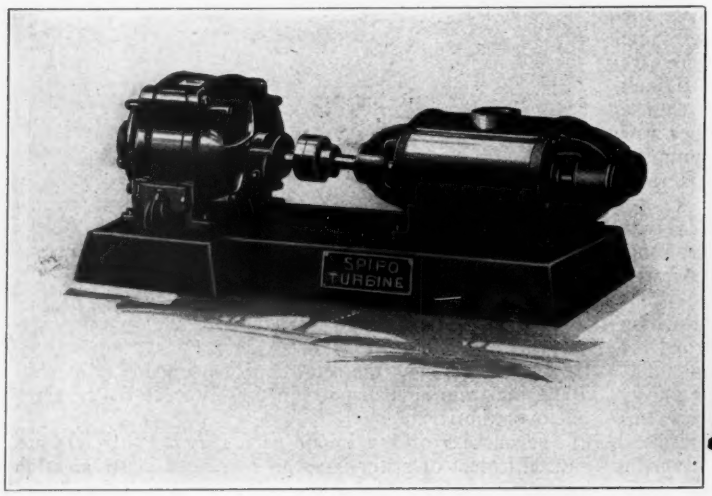


FIG. 2. THE SPIRO DRIVING AN ELECTRIC GENERATOR

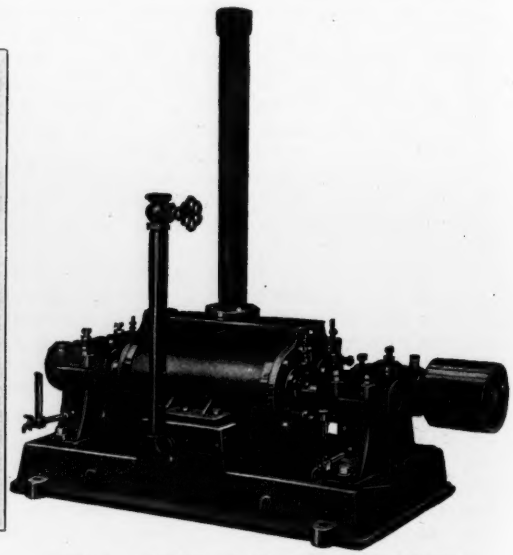


FIG. 3. 30-HP. CLASS B SPIRO TURBINE

auxiliary work, such as induced or forced draft, driving small pumps or centrifugal blowers, and for a number of other purposes, that they are deterred from doing so by the discouraging lack of economy in small size turbines. For them the Spiro will undoubtedly put a new aspect to the matter, as it has been found under test to require no more steam per horsepower hour than reciprocating engine of corresponding size. This places it at an advantage of from 20 to 50 per cent over the ordinary single stage noncondensing turbine and opens up for it a large field, augmented by the small size of the combined outfit, whether pump, fan or other machine.

There are but 2 points of wear in the Spiro turbine, namely, the bearings, and the tooth contact.

In the bearings, the lubricating system is so designed that each bearing acts as an individual pump, circulating oil through the bearing between shaft and bushing, with a positive pressure. This forms a perfect oil film, and as long as there is any oil in the reservoirs or oil chambers which form part of each bearing, this oil film is automatically maintained. Thus there is absolutely no metal, to metal contact in the bearings, all the contact coming upon the oil film. This may be proved at any time by running the turbine and then quickly shutting down and removing one of the heads. As long as this oil film is maintained,—and it will be as long as there is oil in the reservoir,—there will be no perceptible wear on the bearings.

The tooth contact is said to be very satisfactory. The helical gears are the most perfect known for high speed service, smoothly running and of strength far beyond the requirements. The length of the spiral rotors in the Spiro is much greater than would be necessary for the face of spiral gears transmitting equal loads at equal speeds, and as a result the maximum tooth pressure per square inch is limited to 5 lb., while 10 times that amount would be conservative for long wearing power transmitting gears. It has also been discovered that a film or cushion of steam is at all times maintained between the teeth of the rotors, which causes an elastic contact sufficient to produce great smoothness of action.

Tests made upon the Spiro turbine show the following results:

(1)	Boiler Pressure.....	120	lb.
	Initial Pressure.....	101.5	lb.
	Horsepower	25.3	
	Speed 2450		r.p.m.
	Water per B. hp....	53.2	lb. (Noncondensing)
(2)	Boiler Pressure.....	130	lb.
	Initial Pressure.....	115	lb.
	Horsepower	151	
	Speed 2710		r.p.m.
	Water per B. hp....	31.8	lb. (Noncondensing)

Possibly a still more striking example of the great power developed in a small space is furnished by a line of air drills embodying the Spiro turbine, which the Buffalo Forge Co. has been developing, and which will shortly be put on the market. A ¼-in. drill will penetrate hard cast iron 1 in. thick in 12 seconds, or at the rate of 5 in. per minute. The rotors employed in this drill are those shown in the illustration, not larger than the palm of a hand, and to drill iron at this rate requires over ¾-hp. Hundreds of visitors have seen these drills at the shops of the Buffalo Forge Co., and have expressed amazement at the fact that so much evidence of power can be produced from such small rotors. It proves that the principle of the Spiro turbine utilizes substantially all, and wastes very little, of the energy applied.

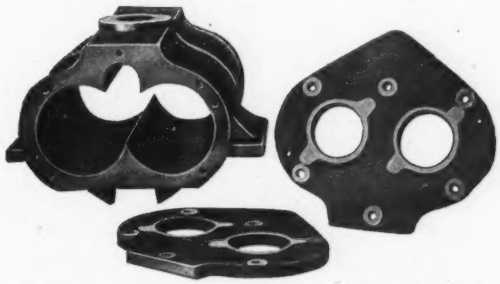


FIG. 5. CYLINDER AND HEADS OF THE SPIRO

QUALITIES OF LUBRICANTS cannot always be judged by the physical tests such as rubbing in the fingers, flash tests, viscosity, etc., because an oil may pass all these tests reasonably well and yet contain ingredients which are at least not beneficial. In a recent chemical analysis of a cylinder oil made by Arthur D. Little, Inc., the cylinder stock was found to be good, but the 6 per cent of fatty oil which was supposed to be tallow was found to be wool grease, which is quite inferior. This shows the necessity in case of any doubt or difficulty with oil of having chemical analysis made to determine the actual constituents of the oil.

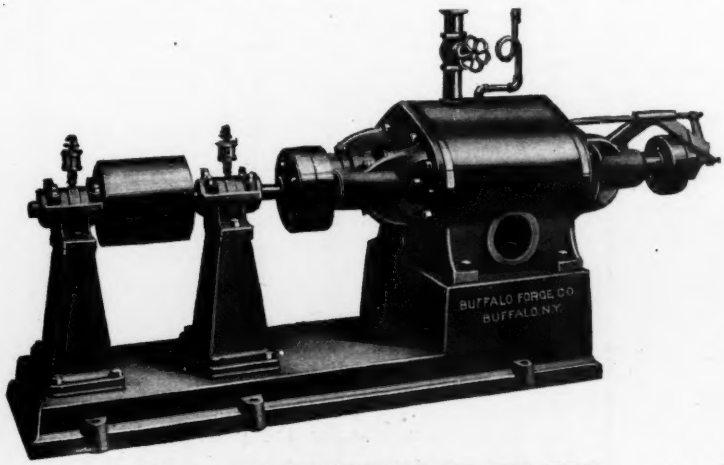


FIG. 4. THE SPIRO TURBINE FOR BELT DRIVE

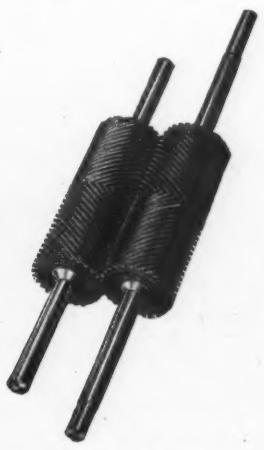


FIG. 6. SPIRO RUNNERS MOUNTED ON SHAFT

EVERY-DAY CALCULATIONS

Arithmetic and The Slide Rule for Figuring Safety Valve Capacity, Horsepower, Pump Capacity and Size, and Economizer Saving

By Richard Howarth

AS A FIRST problem let us commence with the Massachusetts formula for spring loaded safety valves.

How many square feet of grate surface would be allowed for a safety valve 3 in. in diameter under the above law.

A=W×70×11÷P, in which A= area of valve in square inches per square foot of grate area; W= pounds of water evaporated per

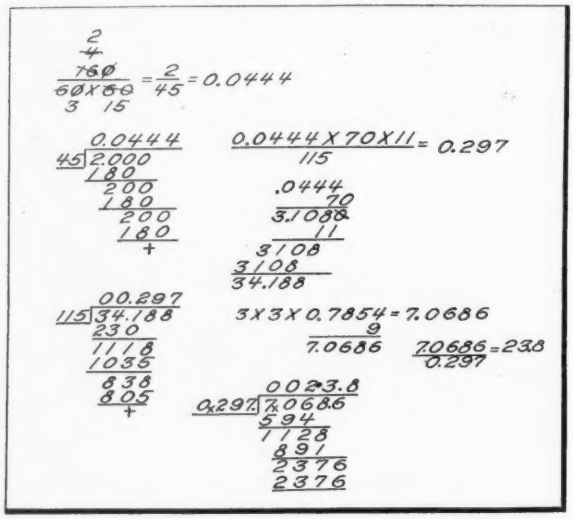


FIG. 1. CALCULATION OF GRATE AREA FOR 3-IN. SAFETY VALVE

second per square foot of grate. P = absolute pressure at which the valve it to open. Of course, the

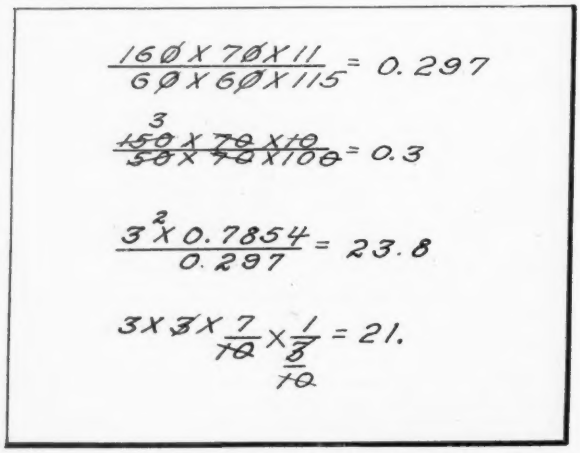


FIG. 2. EXPRESSIONS ARRANGED FOR SLIDE RULE COMPUTATION OF GRATE AREA WITH APPROXIMATE CANCELLATIONS FOR FINDING DECIMAL POINT

valve area depends on the amount of steam generated and its pressure and these values must be chosen to get the valve area correct for the grate used.

Calculation for Grate Area Allowed

ASSUMING that 160 lb. of water is evaporated per hour per square foot into steam at 100 lb. pressure by gage or 115 lb. absolute; then the weight evaporated per second will be, 160÷(60×60)=0.0444 lb. evaporated per second. Substituting in the equation as given above, it becomes 0.0444×70×11÷115=0.297 square inch of valve area to each square foot of grate area. For a 3-in. valve the area is diam.²×0.7854 or 3×3×0.7854=7.0686; now 7.0686÷0.297=23.8 square feet of grate surface.

The Slide Rule Saving

TO do this on the slide rule, bring runner to 16 on A on right hand scale, and 6 on B to the runner; this divides 160 by 60; bring runner to 1 on B and 6 on

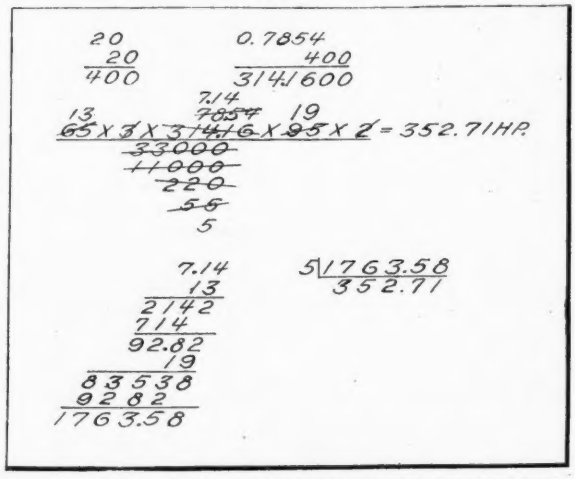


FIG. 4. CALCULATION OF HORSEPOWER AND CANCELLATION TO SIMPLIFY WORK

B to runner, which divides again by 60, and over 1 on B find 444 on A.

Now leaving rule at last setting, viz., 1 on B under 444 on A, which is pounds of water evaporated per second, bring runner to 7 on B, 115 on B to runner and runner to 11 on B, and over 1 on B find 0.297 on A.

To find the area of the 3-in. valve, set runner to 3 on D, which shows 9, the square of 3, under the runner on A; and bring 297 on B to runner; bring runner to 7854 on B and on A under runner find 23.8 square feet of grate surface. (As regards the placing of decimals the reader will find on page 840, of December issue, an article on the placing of decimals on the slide rule.)

Horsepower From the Indicator Diagram

SUPPOSE that the engine is 20 by 36-in. at 95 r.p.m. and according to the planimeter the m.e.p. is 65 lb. per square inch. The first thing to do is to obtain the area of the cylinder. This is D²×0.7854 or 20×20×0.7854=314.16 sq. in. area of cylinder. To calculate the horsepower of engine, take the formula PLAN÷33,000 or 65×314×95×2÷33,000=352.7 hp. of engine. In Fig. 4, after finding the area, substitute values in the horsepower formula; then 3 cancels into 33,000; 5

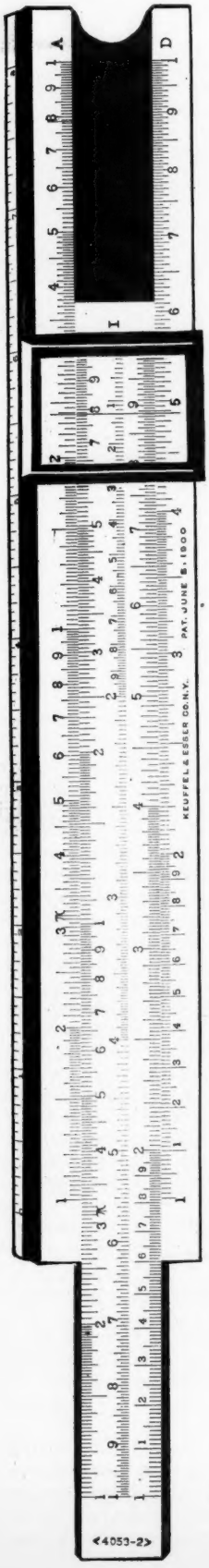


FIG. 3. SLIDE RULE SETTING FOR FINAL CALCULATION; 297 ON B IS UNDER 3^2 ON A, AND RUNNER IS AT 7854 ON B

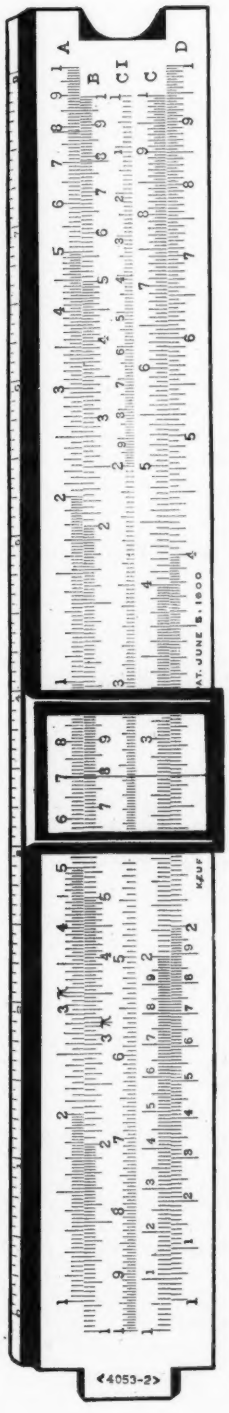


FIG. 7. SETTING OF RULE TO FIND DIAMETER OF PUMP PLUNGER

into 65 gives 13, 5 into 95 gives 19, and these 5s and the 2 makes a product of 50 which cancels into 11,000 leaving 220; 4 into 314.16 leaves 78.54, and into 220 leaves 55; 11 into 78.54 leaves 7.14, and into 55 leaves 5. Performing the operations gives 352.71 hp. as the answer.

Now to do this on the rule, place 1 on B to 65 on A and using runner over 3 on B find 1945 on A; place 1 on B to runner and bring runner to 20 on C, which

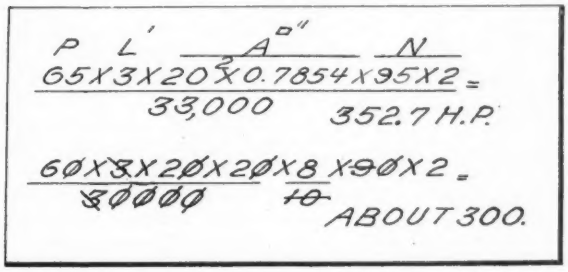


FIG. 5. HORSEPOWER FORMULA ARRANGED FOR SLIDE RULE WORK AND DECIMAL POINT CANCELLATION

gives 20^2 on B. Bring 1 on B to the runner and carry the runner to 7854 on B; now to divide by 33,000, bring 33 on B to the runner, and to multiply by 95, carry the runner to 95 on B; bring 1 on B to the runner and carry runner to 2 on B; on A, the runner indicates 3527, which approximate cancellation shows to be 352.7 hp.

Short Slide Rule Method

ANOTHER method to find the horsepower of any engine is to place 21 on C over diameter in inches, 20 on D; runner to diameter in inches, 20 on C; 1 on C to runner; runner to stroke in feet (36-in. stroke)

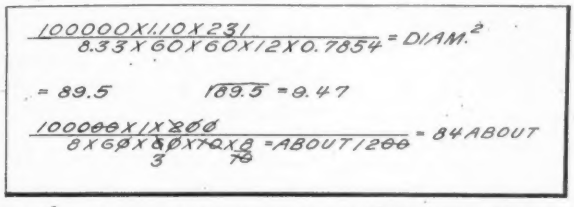


FIG. 6. COMPUTATION OF PUMP PLUNGER SIZE, ARRANGED FOR SLIDE RULE WORK, AND CANCELLATION TO FIND POSITION OF DECIMAL POINT

3 on C; 1 on C to runner; runner to r.p.m., 95 on C; 1 on C to runner; and under the m.e.p., 65 on C find 352.7 hp. on D.

Pump Capacity

SUPPOSE that the engineer has a 3-plunger pump, 8-in. diameter, 12-in. stroke; how many gallons, neglecting slip, is delivered per stroke?

Area in square inches times stroke in inches divided by 231, the cubic inches per gallon, will give the answer; and area equals diameter squared times 0.7854.

Then $8\times8\times0.7854\times12\div231$ when figured out gives 2.615 gallons per stroke for 1 plunger, or 3 times that, 7.845 gallons for 3 plungers.

By the slide rule, set 1 on C at 8 on D; runner to 7854 on B; 231 on B to runner; runner to 12 on B; 1 on B to runner; runner to 3 on B, and on A under runner find 7.854 gal., the answer.

Short Slide Rule Method

SET 294 on B over the diameter in inches, 8 on D; runner to 12 on B; 1 on B to runner; over 3 on B find 7.85 gal. per stroke. Now the number 29.4

on B is a constant to be used when finding the discharge from pumps, and is always set over the diameter of the plunger in inches on D and over the stroke in inches on B find gallons delivered per stroke on A; for a 3-plunger pump, we have multiplied by 3 to get the gallons per revolution.

If it is required to pump 100,000 lb. of water an hour for boiler feed, what size of single acting boiler plunger pump would be required with 12-in. stroke and 60 strokes a minute?

At 8.33 lb. a gallon there would be 100,000÷8.33= 12005 gal. an hour, and 12005÷60=practically 200 gal. a minute; this is not allowing for slip, but for a common boiler feed pump we must allow at least 10 per cent for slip, so that the capacity must be 200×1.10= 220 gal. a minute. Now all that is necessary is to find the area of the plunger. 220×231=50,820 cu. in. a minute, and 50,820÷60=847 cu. in. to be lifted per

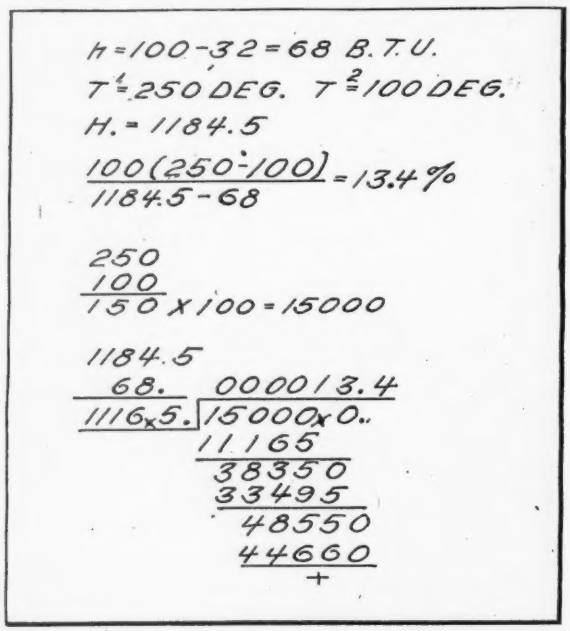


FIG. 8. CALCULATION OF GAIN BY ECONOMIZER HEATING OF FEED WATER

stroke of 12 in.; 847÷12=70.6 sq. in. practically as the area of the plunger, and dividing by 0.7854 gives 89.5 as the square of the diameter; the square root is 9.47 or practically 9½ in. diameter.

Pump Size by Slide Rule

TO do this on the rule, place runner at 100,000 on A, place 8.33 on B under runner, and over 1 on B find 12,000 on A; runner to 1 on B; 60 on B to runner and over 1 on B find 200 on A, this is gallons per minute. Now to add 10 per cent for slip of valves, leave rule at last setting, viz., 1 on B under 200 on A and set runner to 1.10 on B, which shows 220 on A under runner; bring 1 on B to runner, runner to 231 on B; place 60 on B to runner and over 1 on B find 847 on A; this is cubic inches per stroke. Move runner to 1 on B, 12 on B to runner; runner to 1 on B; 7854 on B to runner; over 1 on B find 895 on A. This is diameter squared, and cancellation shows the decimal point to be between 9 and 5 or 89.5. The square root must be somewhere near 9, hence below 89.5 on the right hand scale of B, Fig. 7, find 9.47 on D under the 1 on C. This is the plunger diameter.

Gain by Heating Feed Water

WITH a boiler working at 100 lb. pressure, supplied with water from a hot well at 100 deg. F., what will be the per cent gain by passing the water through an economizer and raising the temperature to 250 deg. F.?

$$\text{Gain per cent} = \frac{100\,(T^1 - T^2)}{H - h^2}$$ in which h = the heat in 1 lb. water at hot well temperature; H = total heat of steam at boiler pressure; T^1 = temperature of feed after heating; T^2 = temperature of feed before heating.

From the data sheets in December issue, the total heat, H, at 100 lb. gage or 115 lb. absolute pressure is 1184.5 B.t.u.; then by substitution of values in the formula as given and calculation as shown in Fig. 8, the per cent is found as 13.4.

The slide rule does not do addition or subtraction, hence the only help it can give in this problem is in the division of 15,000 by 1116.5. As no squares or square roots are involved, it is easier to use the C and D scales because of the coarser readings. Place runner to 15,000 on D; then place 1116.5 on C under runner and under 1 on C find 13.43 on D, which is 13.4 per cent gain due to the economizer.

STARTING A SHUT-DOWN PLANT

By J. M. Conlon

STARTING up an old plant, that was shut down for 2 years, under a new management and by new men is one of the things I had to do on one occasion; and being a stranger in the place I had to satisfy myself that everything was all right before the fire was started under the boilers. Now I know that the readers will agree with me that machinery standing idle for 2 years is very much out of order and will not run as well as if it was turned over every day so the job was not a very easy one.

There was a good water wheel in the plant capable of doing 300 hp. supplied by a canal, and when ever I wanted to turn over any of the machinery I could use the water wheel except in the machine room which was run by steam. The first day was spent tracing pipes and looking over old plans of the boiler room and engine room and from them I carefully examined each and every piece of machinery that was in and around the plant before it was started, the boilers in particular and the engine.

There were 4 horizontal return tubular boilers and a good Corliss engine of 200 hp. I had the boilers inspected by an inspector and he allowed 90 lb. pressure. To my great surprise, I did not find any feed water heater or boiler feed pump or even an injector. There was a tank for holding water that flowed by gravity from the canal and the pipe leading from it was connected to the boiler feed pipe and also to the city service and had the exhaust pipe from the engine connected to it also. So the only conclusion I could come to was that they were feeding the boilers with city water and heating the pipe where it ran as much as they could by exhaust steam.

When the inspector allowed 90 lb. I had the safety valves set for that pressure and, as the water pressure was only 60 lb. in the city service, I insisted on a feedwater heater and a boiler feed pump. After looking over the whole plant I could see an opportunity to

make a much better showing than the previous managment, some of whom were financing the present plan and had figures for every thing but did not know anything about what was in the plant.

As the exhaust steam was used for drying the paper it was allowed to run to waste and I decided to save it and use it for feeding the boilers. So I looked around and found an old tank in the pile back of the boiler house that was used at one time for holding liquors but was out for some time. I took the manhole cover off and had it cleaned out and kept it under city water pressure for quite a while to make sure it was all tight. Being satisfied, I had it placed near the boiler room and in such a position that the returns could enter at the top.

I then ran a 3-in pipe to the outside and put a safety valve in the pipe to blow at 10 lb. pressure.

I then hunted around for a pump for a boiler feed and found a Dean and after overhauling it to suit myself I had it placed near the tank for the returns, connected to the tank and also to the boiler feed pipe line and I was ready to get up steam any time it was wanted.

Now paper mills, as a general rule, run continuously through the week except Sunday and so did this one and under the previous management it burned 20 tons of coal a day of 24 hr. on an average, and that was only guess work, because there were no scales in the boiler room to weigh the coal so that the only way they could tell the coal used per day was by the length of time each pile would last. There were 2 piles each containing so much and the firemen used to make a note of when they started to use from a pile and when it was gone. It was not an accurate way and I insisted on platform scales and having each car weighed so that I could compare the burning.

We did not get running full for some little while but when we did and our figures were compared, there was a decided improvement in our favor. as the amount was cut almost in two and the machines were speeded up, increasing the output because there was a better and a shorter run for the exhaust, and it gave up more heat because it traveled faster.

Steam pipes that were bare, were covered and all leather belts over 4-in. that had been laced were made endless. As long as I remained in the place I can safely say that I was never found wearing the seat out of my trousers in the office except in doing my regular office work.

I stayed until I got the position I now hold and had a very good recommendation from the manager for which I always felt very kindly.

On one day when I was going a month or so one of the firemen who worked for the former manager came around and was surprised at some of the changes, he said they did not need a feed pump in his time as the water was forced to the boilers by the exhaust steam. Now this is something that the readers might like to know it will give them a chance to think and do some figuring how much pressure was carried on the boiler or how much back pressure would be necessary to force water into the boilers; the safety valves were set for 95 lb. when I made the change; the height of the water in the canal above the water line in the boilers, if I remember rightly, was 14 ft. and the water flowed from the canal to the tank from which it was taken to the feed line where the exhaust steam was connected.

WORRY IS brain friction, reduce it to a minimum.

UNEXPECTED DIFFICULTIES

BY R. A. CULTRA

EVERYTHING happens a long time ago, that is a long time before it gets into print, principally because many writers, preferring not to injure the reputation of their friends in the business, refrain from publishing the details until prejudice against them has quietly subsided. In a large manufacturing plant a large engine was being thoroughly overhauled, valve chambers bored out and cylinders rebored, new pistons put in and new boxes and pins wherever needed.

The job had been let to an engine builder who had sent up a thorough mechanic and a first-class apprentice as his helper to do the work. Everything went well during the week until it came to putting in the new crank pin, which had been made and sent up from the shop some 30 miles from the job. It was Saturday morning and the machinist, after being away from home all the week concluded to return, to spend Sunday. But the last train left about 5 p. m., and to catch this he must leave the job about 4:30 p. m. He had worked hard to get the crank hot enough to drive in the new pin, but in spite of all the efforts it was plain that he could not finish the job and catch the train. So, as the crank was almost to the proper heat, he instructed the apprentice to get the sledge hammer and set it beside him to have it handy and, telling him how to enter the pin and drive it home before it had time to expand, he slipped off his overalls and hotfooted it to catch the train.

The apprentice followed the directions in heating the crank and entering the new pin to be driven into the shoulder, but on turning for the sledge to drive it home, the sledge hammer was gone. Laborers were working in an adjoining room on machine work and no one had noticed them borrow the sledge. Without removing the new pin from the hot crank, the apprentice and everyone else tore up the place in haste to find the sledge hammer. By the time it was received, the pin had become quite hot and the crank was also cooling very rapidly.

Without stopping an instant, the apprentice hit that pin good and hard, but it lacked 1½ inches from being up to the shoulder; again he tried to drive it home, but it would not go. Then an attempt was made to drive it back out again, but it was fully expanded by this time and would not move. As it was late in the evening, it was left until Monday morning for the return of the machinist. It can best be imagined what he said when he arrived.

To heat the crank again to extract the pin might result in cracking it owing to the amount the pin would expand. So holes had to be drilled clear through the thickness of the crank for about ⅝ of the circle around the point of that pin in order to drive it out without injuring the crank. This required 3 days' work for 2 men. Then a new pin had to be sent from the shop to replace the one which had been damaged. The machinist put in the second pin himself. Although he was severely reprimanded he did not lose his position, but took a solemn oath that he would not trust another important job to another man.

The apprentice should have looked for the sledge hammer before entering the pin into the hot crank in the first place, but when he saw the hammer was missing, he should have removed the pin to prevent its expanding until the hammer could have been found. So it will be seen that it was the unexpected disappearance of the sledge hammer at the critical moment that caused the trouble, as the pin was carefully calipered and considered a safe fit, having been tried before the crank was heated.

COST OF ISOLATED PLANT POWER

As Generated by Noncondensing Engines With Exhaust Steam Used for Heating During the Winter Season

By American Engine Co.

WHERE steam heating is required, electric power may be generated as a byproduct of the heating plant, at a cost of less than 2c per kilowatt-hour in the majority of cases. The reasons for this low cost of generation may be summarized as follows:

1. The fixed costs, which go to make up a large share of the cost of power, are chargeable only against the additional investment for the plant by which electric power is generated, over and above the investment for the low-pressure steam heating plant.

2. The coal cost chargeable against electric power is reduced, during those periods when the exhaust steam is used for heating, to a small percentage of the coal consumed, representing that part of the heat in the steam, which is lost between the high-pressure boiler and the heating system.

3. The labor charge comprises only the additional labor required, as compared with a low-pressure heating plant. Furthermore, by reason of the additional labor, which is of a higher grade, greater economy is obtained in fuel consumption, amounting to a saving in coal of 5 to 15 per cent, which in a plant of fair size will pay the wages of an engineer.

4. While the charge for oil, waste, repairs, and miscellaneous items is incurred entirely through the installation of the engine and generator, they amount to but a small proportion of the total expense.

Every isolated plant with exhaust steam heating must be considered as a separate problem, because of the wide variation in load, cost of coal, water, labor, etc. The following case, which may be presented as typical, will serve to outline the calculation whereby the cost of power may be determined, and also to indicate the influence on the cost per kw.-hr. of the 3 most important factors, i. e., the fixed charges, the price of coal and the amount of exhaust steam used for heating.

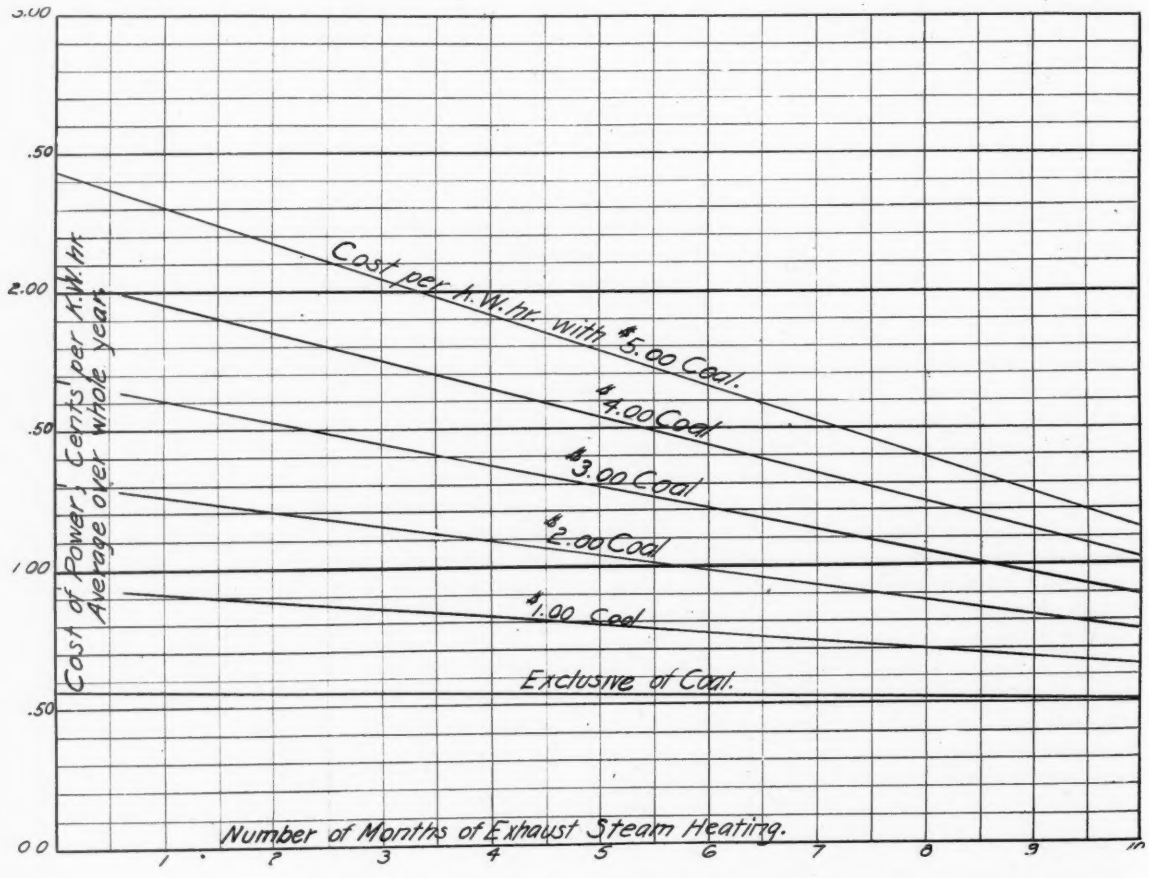


FIG. I. EFFECT OF LENGTH OF HEATING PERIOD ON POWER COST PER KW.-HR.

Fixed Charges

AN industrial plant operating 3000 hours a year, with an average load of 200 kw., will be assumed; 2 100-kw. and 1 50-kw. engine-driven dynamos installed with suitable piping and appurtenances may be set down at $11,000.

Two 200-hp. boilers would be required; but the total cost of these boilers would not be chargeable against power, since boilers would also be required for the low-pressure heating plant. The cost per horsepower of low-pressure boilers, grates, stack, etc., is about the same as for a similar high-pressure equipment. As heat is lost, however, and consumed between the high-pressure boiler and the heating system, a somewhat greater boiler capacity must be installed when power is to be generated.

As the exhaust from an engine contains 80 to 90 per cent of the heat given it, in the boiler, an increase of boiler capacity of 25 per cent over the low-pressure equipment will easily take care of this item and also any additional cost of a high-pressure boiler as compared to a low-pressure equipment. Setting down $18.75 per hp., including boiler, grates, stack setting, piping and labor of installation, the additional boiler cost is 400 hp. $\times$ 20 per cent $\times$ $18.75 = $1500.

This additional boiler cost will vary; in fact in plants already equipped with low-pressure boilers, it will pay to replace the equipment with high-pressure boilers and utilize exhaust steam for heating. The effect of thus increasing fixed charges on the boiler plant equipment will be demonstrated in connection with the charts to be presented.

The 2 largest items of additional first cost, totaling $12,500, have been considered. It might, of course, be profitable to install other apparatus in a plant of this character, as for instance a feed-water heater. But as that piece of apparatus should pay for itself out of the coal saved, it will not be considered under the items of additional first cost.

Of the total additional cost of $12,500, a certain fixed percentage must be charged off every year against the cost of power. The fixed charge may be set down as follows: Interest at 5 per cent; depreciation at 5 per cent; insurance, real estate, upkeep, etc., 5 per cent; total, 15 per cent.

And 15 per cent of $12,500 equals $1,875, which is the fixed charge per year against the additional investment for apparatus to generate power as a byproduct of the heating system.

Labor, Oil Waste, Miscellaneous and Coal

COST for additional labor may be taken as one man at $800 a year, while repairs, oil, waste, packing, etc., may be set down as $250, making a total of $1050.

Coal chargeable against power, comprises the coal equivalent of the heat lost between the high-pressure boiler and the heating system when the heating season is on; when no heating is being done, all of the coal burnt under the boiler is chargeable against power.

Cost for coal will, therefore, depend upon (a) the steam consumption of the engine per kw.-hr, (b) the efficiency of the boiler, or pounds of steam per pound of coal (c) the cost of coal and (d) the percentage of the total amount of steam generated which is used by the heating system.

The steam consumption of an American-Ball Angle Compound engine, as used for isolated plant work, is 26 lb. per horsepower-hour, noncondensing, or 40 lb. per kilowatt-hour. In order to be on the safe side and to take care of the effect of reduced and fluctuating loads on steam consumption, assume 60 lb. of steam per kw.-hr.

Assume boiler efficiency as 60 per cent, or about 8 lb. of steam per pound of coal. The cost of coal and the proportion of the total steam generated which is used in the heating system, are both variable.

In the table given herewith, the cost of coal ranges from $1 to $5 a ton. The amount of steam used in the heating system is taken care of by considering it, as the number of months of the year when the exhaust steam is used for heating. It is assumed that during those months all the exhaust steam is used by the heating system. Strictly speaking, at the beginning and end of the heating season, there are periods when only a moderate amount of heating is required and only a portion of the steam exhausted by the engines is utilized. This decrease in heating load may be taken care of, by assuming a shorter heating season.

For example, suppose that for 4 months during the winter, all the exhaust steam was used in the heating season and that for 1.5 months before and after this season the amount of steam used in the heating system varied from zero to full capacity. It would then be quite accurate to assume that the heating season of 7 months would be equivalent so far as amount of steam used for heating, to a season of 5.5 months in which the heating load was always equivalent to the full exhaust of the engine.

Water

AN average price for water is 10 cents per 1000 gal. During the heating season it is assumed that only 80 per cent of the water is returned to the boiler. During other periods all the water is lost.

It should be noted that it is assumed that in a low-pressure heating system all the water is returned to the boiler; that is, there is no loss, and in setting down the additional cost for water when power is produced as a byproduct, it is assumed that condensation in high-pressure steam piping, condensation in the engine, etc., results in a 20 per cent loss during the heating season and when the steam is exhausted to atmosphere, at 100 per cent loss.

With the fixed costs, labor cost, already given, and calculating the coal and water charges for given conditions, the table and charts shown, were obtained. The following example will serve to explain in detail the method of obtaining these figures.

Cost of a Given Plant

ASSUME the heating season equivalent to 6 months of full load steam heating, during which all the exhaust is used. During this period the coal chargeable against power is the equivalent of the steam and heat lost between the high-pressure boiler and the heating system. Assume that 20 per cent of the heat of the steam is lost in this manner. The other factors entering into the coal cost have already been given, i. e., load 200 kw.; steam consumption 60 lb. of steam per kw. hr.; coal consumption 1 lb. of coal per 8 lb. of steam; hours per year, 3000. With coal at $4, we then have the cost of coal during the 6 months heating period, as follows:

$$\frac{200 \times 3000 \times 60 \times 0.20 \times \$4}{2 \quad 8 \quad 2000} = \$900$$

The part of the year when there is no exhaust steam heating, and those parts of the year when only part of the exhaust steam is used for heating, are equivalent to six months of straight noncondensing operation. The cost of coal is therefore:

$$\frac{200 \times 3000 \times 60 \times \$4}{2 \quad 8 \quad 2000} = \$4500$$

To this coal cost must be added the cost for water which may be set down at 10 cents per thousand gal-

lons. During the heating season, the heating system returns 80 per cent of the boiler feed. The cost for water is then:

$$\frac{200\times3000\times 60}{2}\times\frac{\times0.20\times10c}{8.33\times1000}=\$43.20$$

Table I.

Cost of Power Cents per kw.-hr. in a Typical Isolated Plant. Average Load 200 kw. Heating by Exhaust Steam

Months of Heating	Price of coal per ton. $0	$1	$2	$3	$4	$5
2	0.550	0.880	1.200	1.525	1.850	2.175
4	0.540	0.820	1.090	1.365	1.640	1.915
6	0.531	0.755	0.983	1.205	1.431	1.656
8	0.521	0.700	0.871	1.046	1.221	1.396

For the other 6 months the cost for water is as follows:

$$\frac{200\times3000\times 60}{2}\times\frac{\times 10}{8.33\times1000}=\$216$$

We may now set down the total charges for generating power at the rate of 200 kw. for 3000 hours a year, as follows:

Fixed charge	$1,875
Labor, oil and miscellaneous	1,050
Coal	4,500
	900
Water	216
	43
Total	$8,584

During the year there are developed 3,000×200=600,000 kw.-hr., giving a cost per kw-hr. of

$8,584÷600,000=1.431 cents per kw.-hr.

In the same manner it is found that when the heating season is equivalent to only 2 months of full-load heating, the cost per kw-hr. is 1.85c. For the same conditions when the price of coal is $5 instead of $4, the cost per kw-hr. is 2.175c; and in this way the table shown was compiled.

Charts

FROM this data the charts of Figs. 1 and 2 were prepared. In Fig. 1 the cost of power in cents per kw.-hr. (average over the whole year) is plotted against

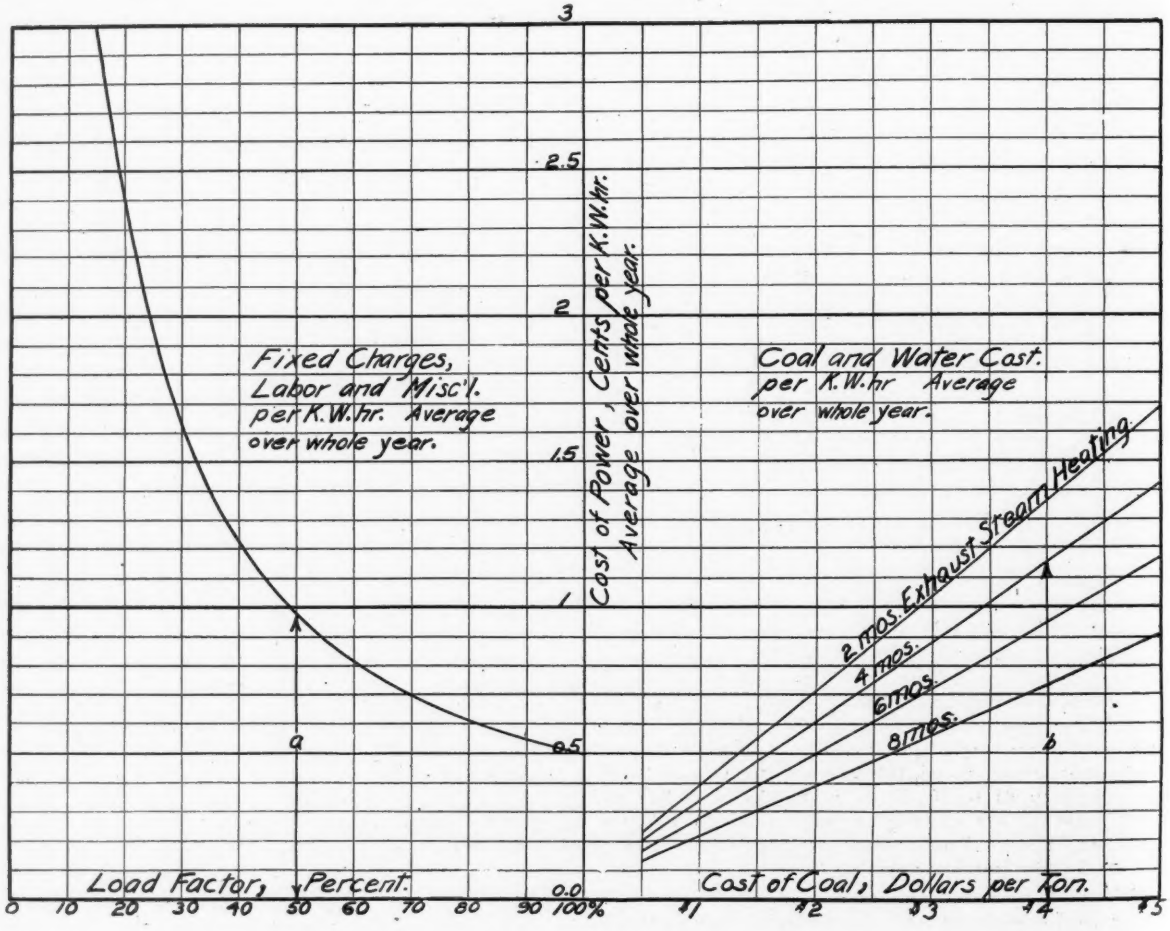


FIG. 2. EFFECT OF COAL COST AND LOAD FACTOR ON AVERAGE POWER COST PER KW.-HR.

the number of months that exhaust steam is used for heating; each line represents a different price of coal. With this chart in hand, we can study the influence of coal cost, length of heating period and also the influence of first cost and of percentage of that cost which should be charged off per year, in order to take care of interest, depreciation, etc.

Suppose, for instance, as has already been suggested, that instead of considering the additional cost of a high-pressure boiler plant, and engine, as against a low-pressure boiler plant, we desire to find out the cost of power in a plant where a low-pressure boiler is already installed and must be replaced. The additional first cost of the high-pressure boiler over and above the low-pressure boiler taking into account the fact that a boiler of higher capacity would be required, was set down in the foregoing analysis at $1500.

Assume that an entire new boiler would be needed costing 5 times this amount, or $7500. This would increase the additional first cost of the plant by $6000 and the additional yearly charges by 15 per cent of $6000 or $900, making the total fixed charge $2,775, instead of $1875, and for 600,000 kw.-hr. a year, would increase the fixed charge per kw.-hr. from 0.312 c. to 0.462 c., or an increase of 0.15 c. The influence of this additional charge of 0.15 c. upon the cost of power with $4 coal, and when 3 months exhaust steam heating is used, is therefore an increase from 1.75 c. to 1.90 c. per kw.-hr.

In the chart of Fig. 2 the cost per kw.-hr. is plotted against the cost of coal in dollars per ton, and each line represents the cost of different lengths of heating periods. This chart is useful for investigating the effect of the price of coal and also the comparative effect of length of heating season and price of coal. For instance, the cost per kw.-hr. is practically the same for an 8 months solid heating season with $4 coal, as it is with a 2 months heating season with $2 coal.

On reference to this chart, it will be noted that the cost exclusive of coal and water are considered separately—being plotted against load factor.

A load of 200 kw. 3000 hours a year is considered as 100 per cent load factor (although the plant capacity is 250 kw.). At 100 per cent the fixed charge, labor charge, etc., per kw.-hr is $\frac{1875+1050}{600,000}$ =0.488 c.

Similarly at at 50 per cent load factor the cost per kw.-hr., exclusive of coal and water is $\frac{1875+1050}{300,000}$ =0.976 c.

By similar calculations the complete curve is plotted, which may be used in connection with the curves at the right in order to study the cost of power under various conditions. Suppose for instance, that the load factor is 50 per cent, then the ordinate a= 0.98 c. for fixed charge, labor, etc.; if the coal cost is $4 a ton and the number of months exhaust steam heating is 4, then the coal and water cost per kw.-hr. is given by b which equals 1.17 c. and the total cost of power per kw.-hr. equals a+b=2.15 c.

Now the question that naturally arises in the minds of the consumer of electric current is this: If the isolated plant with its small capacity and efficiency, further decreased by the fact that it must exhaust its steam for a part of the year to atmosphere, can generate power for 2 cents a kw.-hr., why is it that the central station, in which maximum economy is obtained by cutting down all losses, generating in large units, operating condensing, etc., cannot generate power at a far less cost than this and sell it for a price approximately 1 to 2 cents per kw.-hr.?

The central station can produce power at its own switchboard for a cost including both operating and fixed charges of one cent per kw.-hr. But this is only a part of the total cost to the consumer, since it is necessary to have an elaborate and expensive transmission and distributing system of copper cable, feeders, substations, etc., in order to deliver the power. The power house furnishes electricity to the distributing system, which acts as a carrier and which must pay interest, depreciation, franchise and maintenance charges just as must a railroad. As with the railroad, there is a natural tendency towards rate discrimination, and it is only the favored consumer who obtains power at a reasonable charge, while the other man bears the burden.

NOT A NORTH POLE EXPEDITION

Only a Wail From the January Cold Wave

YOUR libelous epistle of yesterday regarding our Indian half-breed summer has been received and am not at all surprised to hear that the water froze up in all the boilers inside the loop. Last summer I recall that I wrote you that it was quite sultry here and that when we wanted fricasseed chicken all we had to do was to go and borrow one of our neighbor's, that was all dully fricasseed, out of our own garden; and that when we wanted a cross section of prime roast beef it was only necessary to go out to the back 40 and carve a slice or two out of the N. W. ¼ of the S. E. ¼ of section 10 township 12 range 19, on a bay steer and one's appetite would be appeased sufficiently till the sun set; and also that the hogs had to be locked in the cyclone cellar during the middle of the day to keep them from resolving themselves into their original elements of lard oil, spare ribs and butterine.

"Remember?

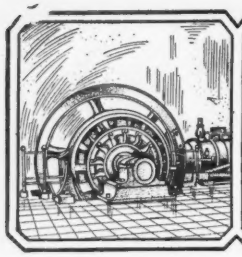
"Well, you came back, if I mistake not, with the statement subscribed and sworn to before a Notorious Republican that in The Loop they used no coal at all and in lieu thereof exposed a few radiators in the sun suitably connected to the engines, and feed pumps, and to all intents and purposes had a flash boiler, with a brine coil on the outside to keep it from melting. Do you recall it?

"Well, now, when I chronicle the startling fact that it is so cold here the past few weeks that it froze up the exhaust and bent it, froze up the vacuum in the condenser and that we had to blast the smoke out of the stack and wheel it out in chunks and put felt boots on the feet of the grand piano to keep it warm, you come back with the statement that the steam froze up in Johnnie McGrath's boiler, that the air in the Fisher Building froze so hard that the elevators had to have ice breakers on and that Alfred Johnson couldn't run the Mandel Bros. store because the coal froze to the grate bars and that all their watered silk froze up and was a total loss.

"Well, that's nothing.

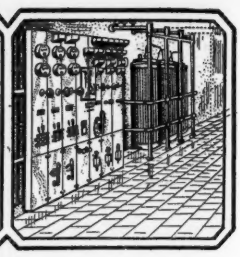
"As I was coming to work today noon I heard a rifle shot and then a series of exclamations such as a dog might utter when he has a chunk of lead thrust into his digestive apparatus. Then out of the frosty breeze a puff of flame and warm air struck my face. This seemed singular as no one was in sight. Suddenly I remembered that 3 weeks ago one warm day when it was 58 deg. below zero in the shade, I paid my respects to Gallagher's dog and what I heard was his remarks and the crack of the rifle thawing out.

"Yes, it is cold up here—a little!"



Electrical Machinery

For Generating, Transmitting and Using Current



INDUCTION MOTORS

Installation, Operation and Care

By Carl D. Knight

IT IS THE PURPOSE of this article to bring out the more important points in handling polyphase induction motors. Many of these directions may be applied to the single-phase motor also, but as there are not yet on the market well determined general types of single-phase motors, no specific directions can be given for their operation.

There are now in general use 3 types of polyphase induction motors, the squirrel cage, internal resistance, and external resistance, the construction of the rotor determining the class to which the motor belongs.

The squirrel cage motor is the simplest and most common. Figures 1, 2 and 3 show respectively, a squirrel cage type induction motor, a stator and a rotor. The roter winding consists of heavy copper bars placed in slots in the armature iron, and connected together at the ends by heavy copper rings. Its more important characteristics are, no moving contacts, small change in speed from no load to full load, and rather poor starting torque. In order to prevent the motor from taking too large a current from the line at start, auto-starters or starting compensators are used with sizes larger than 5 hp. An auto-starter or compensator is a transformer which reduces the voltage applied to the motor at start, and is cut out after the motor has attained its speed leaving normal voltage applied to the motor.

Figures 5, 6 and 7, show respectively the winding diagrams of a 2-phase squirrel-cage type of polyphase induction motor; a 3 phase open or star winding and a 3-phase delta-connected winding for a motor of the same type.

The internal resistance motor has its armature wound with wire and this winding connected to a resistance placed inside the armature, and so arranged that it may be cut in or out from outside. This resistance is cut in at start and gradually cut out as the motor speeds up. It is not to be used in any case as a speed regulator. The cutting in and out of resistance is accomplished on small machines by a knob projecting from the end of the shaft on the end opposite the pulley. This knob is pulled out to cut resistance in and pushed in as the motor speeds up. On larger sizes the same result is obtained by means of a lever placed on the end frame of the motor. This type of motor has a greater change of speed with load than the squirrel cage type, but has a greater starting torque. No auto-starter nor starting compensator is required, simply a switch in the supply wires. Figures 8 to 11 inclusive, show respectivelly 2 types of internal resistance motors with their rotors.

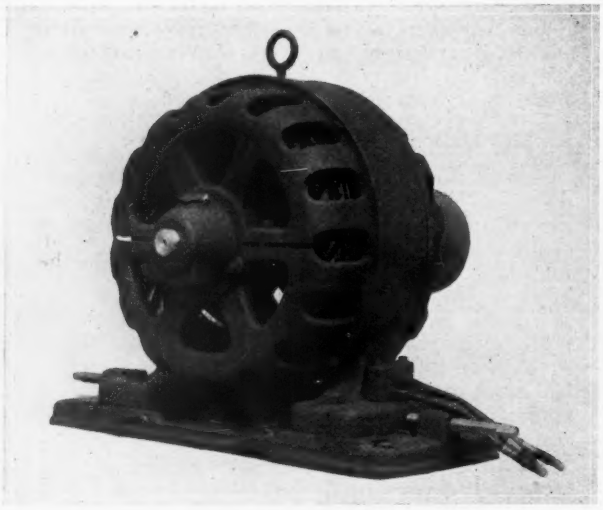


FIG. 1. WESTINGHOUSE SQUIRREL-CAGE TYPE POLYPHASE INDUCTION MOTOR

FIG. 2. STATOR OF WESTINGHOUSE SQUIRREL-CAGE TYPE POLYPHASE INDUCTION MOTOR

The external resistance motor shown in Fig. 12 and its winding diagram in Fig. 13, has its armature winding connected through slip rings and brushes to a resistance placed externally to the motor. This type of motor is usually used where a variable speed polyphase motor is needed. Its speed variation with

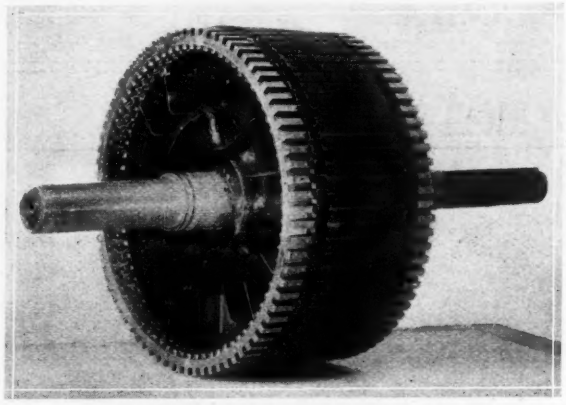


FIG. 3. ROTOR OF WESTINGHOUSE SQUIRREL-CAGE TYPE POLYPHASE INDUCTION MOTOR

load is quite large and the starting torque much larger than either of the other 2 types. A controller is usually used with this motor to start, reverse and change speed by change of resistance.

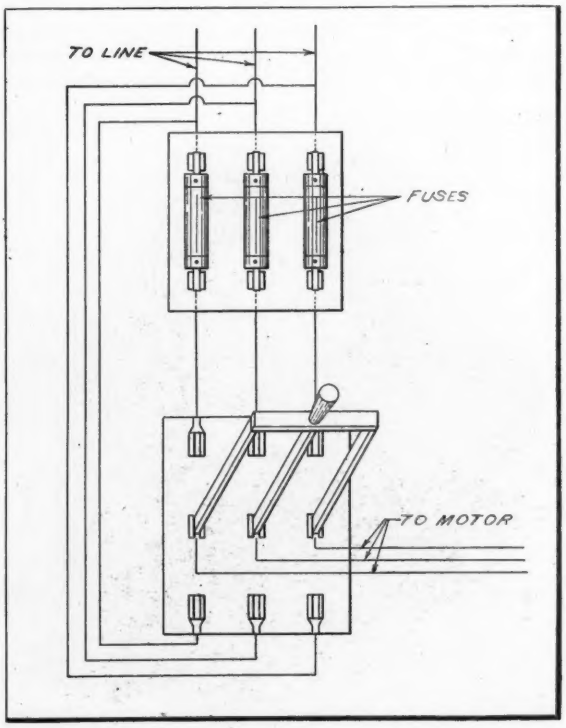


FIG. 4. METHOD OF STARTING SMALL SQUIRREL-CAGE TYPE POLYPHASE INDUCTION MOTORS

The choice of location for a motor is influenced somewhat by its type. The squirrel-cage type for example, having no moving contacts, may be placed in a position much more exposed to dust than the other 2 types. The internal resistance type must be located in a position such that the starting knob or lever may be easily reached by the attendant.

Motors are usually shipped from the manufacturers assembled, but in case it becomes necessary for any reason to dismantle and reassemble an induction motor the principle precaution necessary is to avoid damage to the windings. In unpacking a new motor, look for the instruction book which all manufacturers place in the crate or attach to the machine. This will give any special directions necessary for that particular motor. It is practice with some manufacturers to ship with each machine a metal gage for checking the air gap, or clearance between the rotating part and the stationary part. This gage is a steel strip from 12 to 18 in. in length and ½ to ¾ in. in width. Its edges

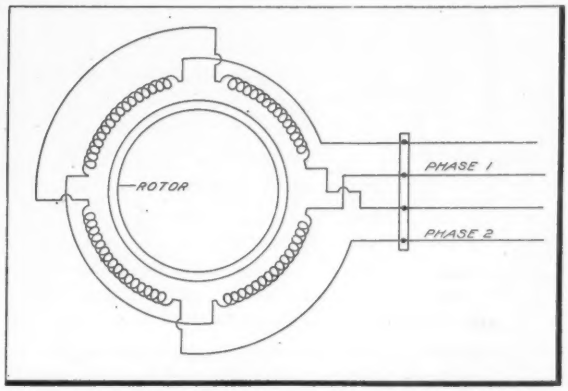


FIG. 5. WINDING DIAGRAM OF A TWO-PHASE SQUIRREL-CAGE INDUCTION MOTOR

are beveled back from one side so as to fit approximately the curvature of the stationary part. This gage should always be carefully preserved for future use as will be described later.

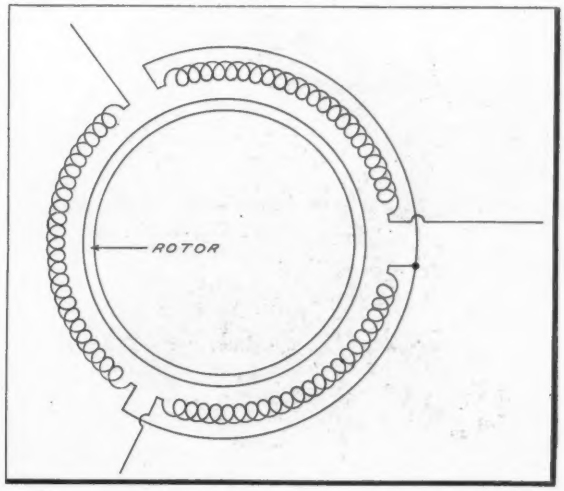


FIG. 6. THREE-PHASE SQUIRREL-CAGE TYPE INDUCTION MOTOR DIAGRAM, OPEN OR STAR WINDING

It is oftentimes necessary or more convenient to mount motors on side walls or ceilings instead of on the floor. Any induction motor is easily adapted for mounting in either of these positions, the only change necessary being to remove the bolts holding the end brackets to the main frame and turn the brackets through 90 or 180 deg. as the case may be. This is necessary in order to bring the oil wells right side up.

In making this change especially on the larger sizes of motors, it is best to arrange to take the weight of the armature from the bearings. This may be done on the pulley end by blocking up tight under the pulley or shaft. On the opposite end of the armature the same result may be brought about by placing a wooden wedge or shim between the armature and the stationary part.

In placing the motor in position care should be taken to avoid rough handling. It is best not to remove the motor from its shipping skids until it is as

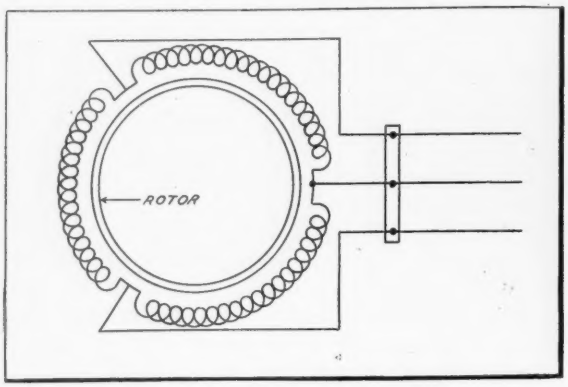


FIG. 7. THREE-PHASE SQUIRREL-CAGE TYPE INDUCTION MOTOR WITH DELTA-CONNECTED WINDING

near as possible in position because it is much easier rolled along the floor if on skids. The final location can usually be easiest made by means of a chain hoist. In cases where the motor has no eye bolt in the top or where it is to be mounted on a side wall, a rope sling looped under the bearing supports makes a convenient method of grappling. For ceiling mounting the final location will usually have to be made by supporting the motor from below.

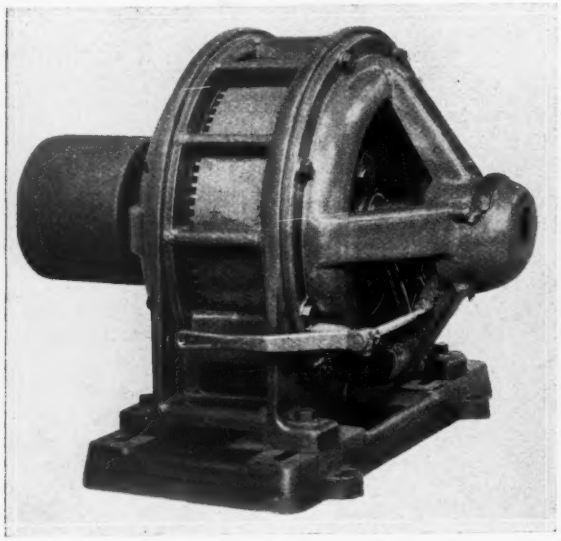


FIG. 8. GENERAL ELECTRIC INTERNAL RESISTANCE TYPE OF MOTOR WITH GRID RESISTANCES

Always be sure before bolting the motor in its final position that the shaft is level. This is necessary in order that there shall not be a tendency for the armature to hug against the bearing linings and cause undue heating.

Fill the bearings with good light oil, being careful not to allow the oil to run over onto the windings. If oil is accidentally spilled upon the windings it should be wiped up as soon as possible, for although oil is an insulator itself, it has a softening effect upon insulation, and will in time seriously damage it.

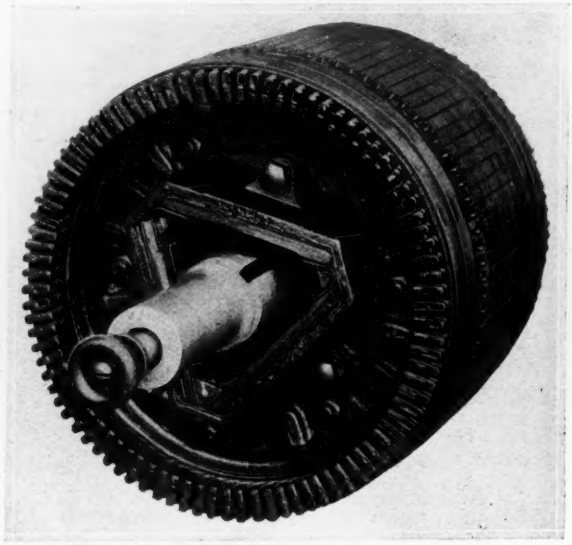


FIG. 9. GENERAL ELECTRIC INDUCTION MOTOR ROTOR WITH GRID RESISTANCES

The electrical connections should be made temporarially until it is known that the direction of rotation is as desired. Three-phase machines having compensators should have the 3 wires from the line connected to the terminals of the compensator marked line, and the 3 terminals of the motor connected to the terminals of the compensator marked motor. The order in which

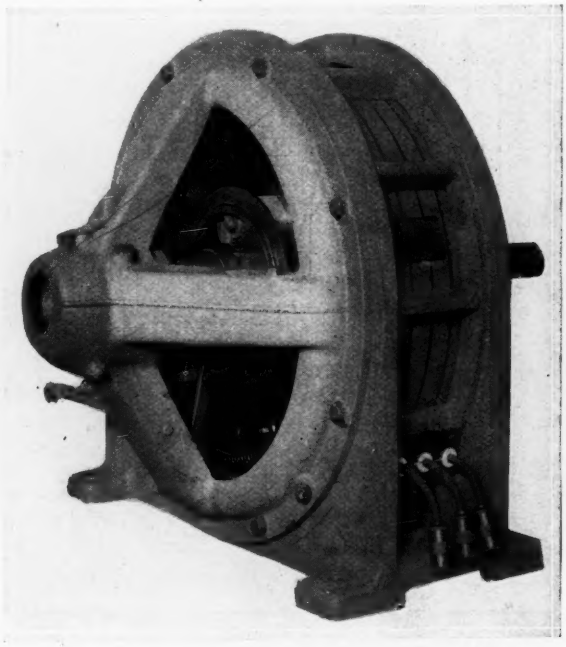


FIG. 10. GENERAL ELECTRIC INTERNAL RESISTANCE TYPE OF MOTOR WITH EDGEWISE-WOUND RESISTANCE

the wires are taken will make no difference; that is, any one of the line wires can be attached to any one of the line terminals of the compensator. In the case of 2-phase machines it is necessary that the wires belonging to each phase be known and connected in their proper places. On standard motors having their 4 terminals brought out in a row, terminals 1 and 3

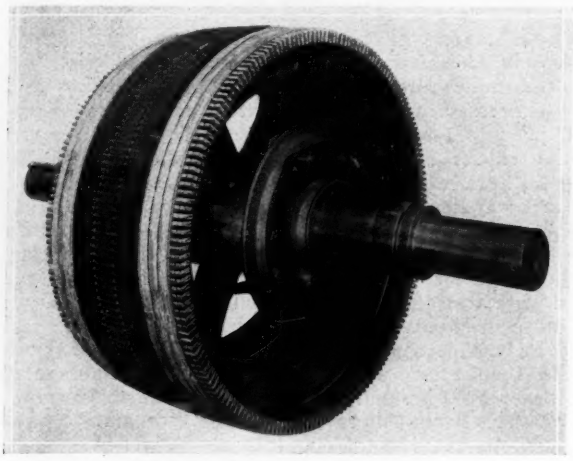


FIG. 11. GENERAL ELECTRIC INDUCTION MOTOR ROTOR SHOWING EDGEWISE-WOUND RESISTANCE

are usually one phase and terminals 2 and 4 the other, it making no difference from which end the numbering is made. If there is any doubt about these being the terminals of a phase in any particular machine, they may be tested out by means of the ordinary testing magneto or a door bell and battery. The terminals

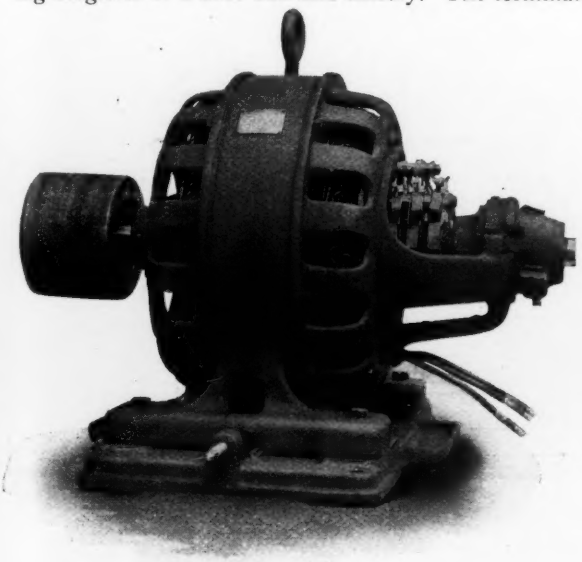


FIG. 12. WESTINGHOUSE EXTERNAL RESISTANCE TYPE OF POLYPHASE INDUCTION MOTOR

between which the bell will ring are the terminals of a phase. There should be no connection between the phases in a 2-phase motor.

If the wires of any one phase of the supply are not known they may be determined by the use of a voltmeter or a string of incandescent lamps connected in series, the combined voltage of the lamps being equal to the voltage of the supply.

Small motors of the squirrel cage type having no compensator should be provided with a starting switch similar to the switch shown in the diagram Fig. 4. It is so arranged that throwing the switch down starts the motor without the fuses being in circuit. After the motor has attained its speed the switch is thrown up cutting in the fuses. This enables the motor to be fused for its normal running current, although the current at start may be several times as great. The arrangement for 2-phase motors is similar.

Motors having internal resistance armatures have simply a single throw fused switch in the supply line.

In case of a motor having external resistance for the armature, the wiring is usually special for each motor and a diagram of connections should be obtained from the maker if none is with the motor.

When the electrical connections have been made the motor may be started with the belt off, and if the

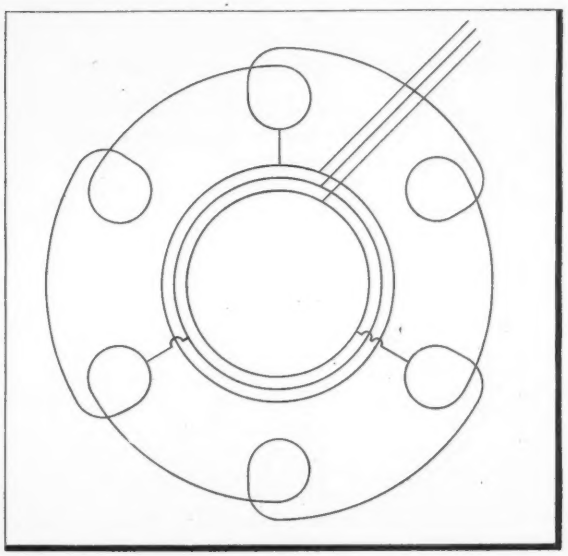


FIG. 13. WINDING DIAGRAM OF EXTERNAL RESISTANCE TYPE ROTOR

directions of rotation is correct, and no other trouble appears, the temporary joints in the leads may be made permanent by soldering. In doing this do not use acid as a soldering flux. Make sure the wires are scraped clean at the joint and use rosin or some of the commercial soldering fluxes which do not corrode the wire. A flux which corrodes the wire will make a poor joint in a short time. After soldering, carefully insulate the joint with tape.

After the motor has been put into service it should be carefully watched for several days for defects and undue heating.

PAINT WHICH INDICATES changes of temperature by a change in color can be made, according to the Mechanical World, by a mixture of 7 parts of saturated solution of potassium iodide and 134 parts of saturated solution of mercuric chloride with 1 part of pulverized copper sulphate and the necessary oils and driers. The paint changes its color between 115 and 130 degrees F., and can be applied to any surface of which it is desirable to determine the temperature. The range of temperature at which the color-changes take place may be slightly varied by altering the proportions of the ingredients.

INCANDESCENT LAMP DATA

The Relative Cost of Operating Various Types

MUCH has been written about high efficiency incandescent lamps and their manufacture in which all engineers in charge of a plant would be interested, but as to just what the saving in the annual cost of lighting a building would be by substituting a metalized filament, tantalum or tungsten lamp for the old carbon filament lamp is a matter of importance to all operating men.

In making a comparison of costs the consumption in watts per candlepower is not the only factor as the cost of the lamp must be considered. Tantalum and tungsten lamps are much more expensive than the carbon filament lamp, therefore, the reduced current consumption is not the true basis for figuring costs.

Before making comparisons a few explanations will, perhaps, make the meaning of the terms used more plain.

The metalized filament lamp which consists of an electro-plated carbon filament is known commercially

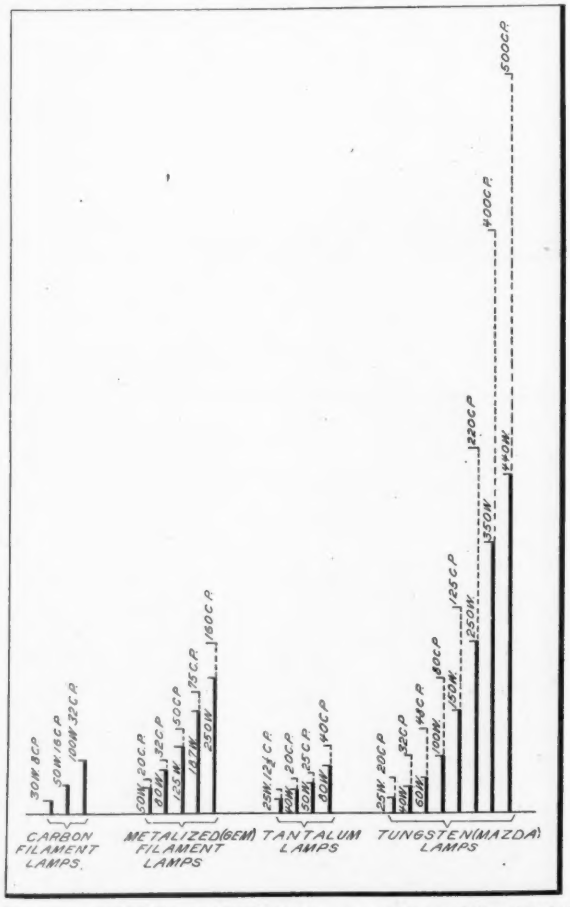


FIG. 1. GRAPHIC ILLUSTRATION OF THE COMPARATIVE EFFICIENCIES OF VARIOUS TYPES OF INCANDESCENT LAMPS

as the Gem lamp. The tantalum lamp derives its name from the metal composing its filament, and standard tungsten lamps of American manufacture bear the trade name of Mazda. This name was adopted by the National Electric Lamp Association to denote the highest efficiency type of incandescent lamp which now has a tungsten filament. If in the future a more suitable or a more efficient material is discovered the name Mazda will still apply to that lamp.

The use of the term efficiency in connection with an incandescent lamp is somewhat misleading as it is expressed in watts consumption per candlepower.

Figure 1 is a graphic illustration of the comparative efficiencies of the various types of lamps. The solid lines represent watts consumption and the dotted lines candlepower. Both the wattage lines and the candlepower lines are drawn to scale with the carbon filament lamp as a basis, lines being equal in length in the latter type. It will be seen that the proportionate wattage line falls rapidly as the Gem, Tantalum and Mazda lamps are reached successively.

The accompanying table shows the cost of operating the 4 types of lamps an hour based on an average life of 1000 hr. and the cost of current at 10 cents a kw.-hr. From this table it will be comparatively easy to figure the cost of operating any number of lamps. The cost of current is of course not arbitrarily given and any figure can be substituted by making the last two columns correspond to such a change.

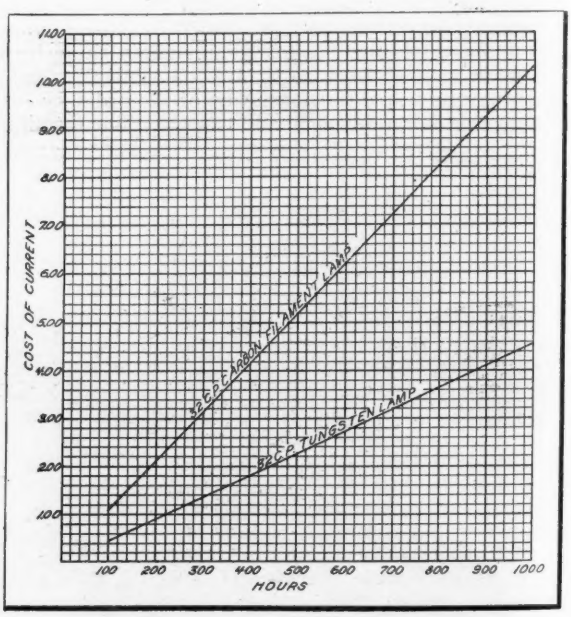


FIG. 2. RELATIVE COST OF OPERATING A CARBON FILAMENT AND TUNGSTEN LAMP

Figure 2 is a diagram showing the relative cost of operating a 32-cp. carbon-filament lamp and a 32-cp. tungsten lamp from 100 to 1000 hr. This candlepower is taken as it is the only similar rating of both types.

As an illustration let it be assumed that an office building has an installation of 1000 32-cp. lamps which if burned an average of 5 hr. a day for 26 days in the month would, with current at 10 cents a kw.-hr. cost approximately $1,330 for operation. An equal number of tungsten lamps of the same candlepower burned under the same conditions would cost approximately

$587. These figures, of course, include the cost of the lamps.

As will be seen by reference to the table the tantalum lamp has a small advantage so far as cost of operation is concerned over the tungsten lamp if the consumption of current and cost of lamp are both considered.

TABLE SHOWING COST PER HOUR FOR OPERATING THE VARIOUS TYPES OF INCANDESCENT LAMPS ON A BASIS OF 1000 HOURS AVERAGE LIFE AND CURRENT AT $0.10 PER KILOWATT HOUR.*

Candle Power	Watts	Cost of lamp per hour, Dollars.	Cost of current per hour, Dollars.	Total cost per hour, Dollars.
Carbon Filament Lamps				
8	30	.00013	.00300	.00313
16	50	.00013	.00500	.00513
32	100	.00020	.01000	.01020
Metalized (Gem) Filament Lamps				
20	50	.00017	.00500	.00517
32	80	.00025	.00800	.00825
50	125	.00033	.01250	.01283
75	187	.00047	.01870	.01917
100	250	.00060	.02500	.02560
Tantalum Lamps				
12.5	25	.00030	.00250	.00280
20	40	.00030	.00400	.00430
25	50	.00030	.00500	.00530
40	80	.00057	.00800	.00857
Tungsten Lamps				
20	25	.00047	.00250	.00297
32	40	.00052	.00400	.00452
48	60	.00070	.00600	.00670
80	100	.00095	.01000	.01095
125	150	.00140	.01500	.01640
220	250	.00215	.02500	.02715
350	400	.00350	.04000	.04350
440	500	.00375	.05000	.05375

*NOTE:—The costs of the lamps are based approximately on the net cost when purchased in very large quantities and will be somewhat higher for small lots.

As an illustration the 20-cp. tungsten and tantalum lamps can be compared. Taking the figures from the table the cost of operating the tantalum lamp for 1000 hr. would be $4.30 and that of the tungsten lamp $4.52.

The sale of the tungsten lamp has been pushed much harder than the tantalum lamp however, and is more largely used which is undoubtedly due to some good reason on the part of the manufacturers.

THE COMMITTEE ON INSURANCE of the American Electric Railway Association, at the organization's 1911 convention, stated:

"So far as the committee has been able to ascertain, the insurance companies have not been called upon to pay one dollar in the past year on account of a fire in any car house or other buildings equipped with automatic sprinklers. You who have protected your buildings with automatic sprinklers may use this statement as an argument for reduced rates; you who have not protected your buildings may use it as an argument for so safeguarding your buildings as to prevent fire."

ELECTRIC MOTOR DRIVE FOR MACHINE TOOLS

THE advantages of electric-motor drive for machine tool work are so well recognized that it will be unnecessary to dwell on them in this article.

When changing over from mechanical transmission of power to individual electric motor drive, or when installing new machines, the question of the power requirement of each machine is important. There has been comparatively little information published on this subject and the diagrams, shown in Practical Reference Tables, Figs. 1 to 5 inclusive, are given as a help to the engineer or electrician who has to determine the type and capacity of the motors.

Machine tools operate under varied conditions and it is therefore impossible to give the exact horsepower required for any given machine. It is possible, however, to determine within reasonable limits, which are close enough for ordinary use, what power a machine tool will require for its operation.

The diagrams are made up of figures representing average American practice and are based on the assumption that water hardened steel tools are used at an average cutting speed of 20 ft. a min. unless otherwise stated. The horsepower required for the machine will increase approximately in proportion to the cutting speed and by a simple calculation the power required for any cutting speed can be determined.

There are 2 general classes of machine tools, those having a rotary motion such as lathes, boring mills, milling machines and drills, and those having a reciprocating motion which include planers, shapers, slotters and machines of similar character.

Motors to be used for lathes, boring mills and drill presses should be of the shunt-wound adjustable-speed type with good inherent regulation. Machines having a reciprocating motion are from their nature less productive than a machine with a purely rotary motion. For this reason it is especially important that the former type be run to the limit of capacity. Compound-wound adjustable-speed motors should invariably be used for machines with a reciprocating motion as the compound winding assists materially in reducing the inrush of current at the instant of reversal when the torque required of the motor is abnormally high. To still further aid in holding the inrush of current within reasonable limits the use of a flywheel, is good practice.

COSTS OF OPERATION of motor trucks is interesting in view of the increasing use of such vehicles. One firm gives the following:

Capacity	Daily Mileage	Daily Cost
2 tons	70	$10.60
3 tons	62	12.20
4 tons	55	13.80
5 tons	50	15.00

From another company the costs are given as: 1-ton, $8.07; 2-ton, $10.25; 3-ton, $11.30; 5-ton, $14.80; 7-ton, $16.45; 10-ton, $18.50, a day.

For a 1500-lb. wagon averaging 70 miles a day, the cost is given as $3.20, but this does not include storage, garage work nor insurance, as do the tables above. Drivers' wages are figured at $16 to $22 a week; gasoline at 12 cents a gallon, and oil at 30 cents; garage at $225 to $300 a year; tires at $275 for a 1-ton and $1650 for a 10-ton machine; overhauling and repairs at $300 to $550; depreciation at 15 per cent, interest at 5 per cent and insurance for fire and liability at $150 to $240 a year.

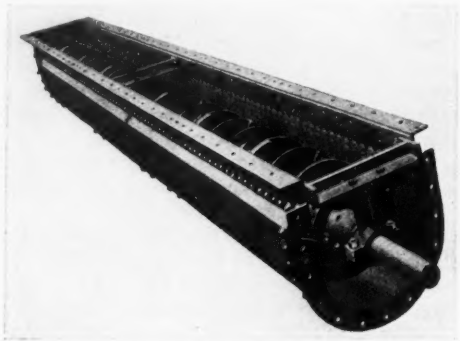
SCREW CONVEYORS

Mechanical Handling of Coal and Ashes Short Distances or in Small Quantities, Capacities, Power Required and Operating Costs

By Reginald Trautschold

TWO systems of conveyors have been discussed in previous issues, the belt conveyor with its comparatively high initial cost but low operating and maintenance expenses and the flight conveyor with a relatively low initial cost but increase in the expense for operation and maintenance, are particularly adaptable where a large and continuous supply of coal to the power house proper is necessary. In many plants, however, the necessity for large capacity in the handling of fuel does not exist and systems such as have been described could be used, even in the smallest obtainable size, only intermittantly which which would prevent economical operation.

A system permitting smaller capacity and of lower initial cost must therefore be installed, and a type of apparatus that is popular, and frequently the most satisfactory, is the screw or spiral conveyor. This system consists of a screw, formed by a ribbon or flight wound spirally about a shaft, revolving in a trough which it fits more or less closely and possesses the advantages of low first cost and compactness of apparatus, permitting installations entirely underground or in limited passages. Conveyors of such size as to permit continuous use may also be obtained, thus enabling the full economic value of the system to be approached.



SCREW OR SPIRAL CONVEYOR

Such conveyors sometimes find an important field in large power plants, although the conveying problems that have been discussed in this series were solved without the employment of screw conveyors. Cases do exist, however, where such conveyors are valuable and economical installations. For instance; Plants in which the main storage is contained in overhead bunkers may have their boilers so located as to make impossible the feeding of the coal to the grates or stokers by gravity, this arrangement perhaps due originally to local limitations of space necessitating the location of the boilers in certain positions, or to additions to the plant compelling the new boilers to be situated some distance from the coal bunkers. In such cases screw conveyors are economically installed to carry coal from the bunkers to the grates, as a conveyor of limited capacity is just what is needed. This comparatively small but continual demand for fuel by the grates also permits the use of screw conveyors for keeping supplied the auxiliary coal bunkers, from which the coal is drawn directly for consumption, as the demand for coal is no greater than its consumption and the continuous use of an average screw conveyor will meet the requirements of a good sized plant.

In the handling of ashes the screw conveyor finds a wide field as the proportion of ashes to coal is about 1 to 6, although, the problem is one that is difficult of solution. Hot ashes cause warping in all conveyors and the ash dust entering the bearings rapidly destroys the shafts, but with the screw conveyor the destruction from such causes is a minimum. When the ashes are quenched the water after leaching the ashes is highly corrosive and seriously eats into the metal parts of any conveyor, a screw conveyor perhaps more than any other. This makes it advisable not to quench the ashes before delivery to the conveyor or, if quenched to supply only enough water partly to cool the ashes, so that all superfluous water may be evaporated before the ashes are removed to the conveyor.

The conveyor should also be located under a section of the ash pit as far removed from a position directly under the grates as possible, so that the ashes may be gradually raked over to the receiving hopper of the conveyor and thus cooled before delivery to the screw. The trough of the conveyor in which the screw revolves should also be considerably heavier than is necessary for conveyors handling coal, usually of cast iron.

In practically every installation of screw conveyors some other appartus for elevating purposes is required, as this type of apparatus can be inclined only a small amount without sacrificing its mechanical efficiency. Machinery for raising the load to be delivered to a screw conveyor or to elevate the discharge from one will be taken up later.

Capacity

THE load a screw conveyor is capable of carrying is represented approximately by that amount of material that would lie in a trough closely fitting the screw to a depth of about one-third the diameter of the screw, the capacity of the conveyor depending, of course, upon the speed at which the load is propelled along the trough, that is, upon the revolutions made by the screw per minute, or speed of conveyor. The efficient speed is considerably higher for conveyors of small diameter (diamter of screw) than for those of large diameter, and though this question of speed is one upon which no 2 authorities seem to agree, the revolutions of the screw per minute as given in the table on the capacity of screw conveyors in the Practical Reference Tables is good practice.

At other than the speeds given in this table the capacity varies directly, and the difference in capacity of conveyors handling ashes and those conveying coal is proportional to the respective weights of the 2 substances. The capacities, as given, are for horizontal conveyors and though an inclination of as much as 10 deg. will not materially effect the capacity, screw conveyors should seldom be installed at such a steep grade and never at an angle much exceeding such inclination. One other limitation of the screw conveyor which might be mentioned here, is that coal in large lumps or run-of-mine cannot be economically handled.

Power

POWER consumed by a belt conveyor in carrying one ton of material any specified distance is greater than in the case of either of the other 2 systems that have been discussed, as a screw conveyor is virtually a flight conveyor in which the flights propel the load by a force applied obliquely to the direction of travel instead of normally as in the case of a true flight conveyor. As in the cases of any mechanical system for handling materials the power required is used in 2 distinct operations: 1st, to run the apparatus and 2nd, to carry the load. This point is emphasized as the general practice in deriving the power required for a screw conveyor is simply to multiply the load conveyed per unit of time by the length of the conveyor and by a fixed constant, or set of constants, one for each class of material handled. This practice implies that the same amount of power is required to convey a given load a certain distance irrespective of size of conveyor.

Such, however, is not the case, as each size of conveyor requires a different amount of power to drive the apparatus, and this power also varies with the speed at which it is driven. In the derivation of the following formula for horsepower given in the Practical Reference Tables this fact has been taken into due consideration and the results obtained from its use give horsepowers which are actually required for any screw conveyor handling coal or ashes, up to the capacities given in the table of capacities, provided the load carried is in normal condition. If ashes should be quenched and delivered to the conveyor in a wet and sticky condition, however, as much as 50 per cent more power may be required for the proper operation of a conveyor to handle them. The horsepower formula applies only to horizontal conveyors; for one that is inclined, it is necessary to add 2 per cent for each degree of inclination, up to a maximum of 10 degrees.

Initial Cost

GIVEN the capacity in tons per hour, the fact that both capacity of screw conveyor and cost depend upon its size (diameter of screw) permits a close approximation of cost in terms of tons handled per hour being reached. It is true that the cost of such a conveyor does not vary directly with its size but this is also true of its capacity, as a screw conveyor of large size is operated at a slower speed than a small one. It is a fact that a screw conveyor with a cast-iron trough costs more than one with a steel trough but the difference is about constant, that is, the additional cost is about proportional to the size of the conveyor. These relations expressed in a convenient form are given in the table on the approximate cost of a screw conveyor outfit in the Practical Reference Tables. Such values include the cost of all necessary apparatus (exclusive of the power unit) required for an ordinary installation, and may be safely used upon which to base an intelligent estimate.

Operating Cost

THE net operating cost of a screw conveyor, consisting of the cost of operation, cost of maintenance and the burden of interest, taxes and insurance, does not represent its economic value as does such expense in the case of the other systems that have been discussed. The fact that the field covered by the screw conveyor cannot be taken care of economically, under all conditions, by the belt or flight conveyors discounts the greater net operating cost of the screw conveyor. Although the net operating cost does not represent the intrinsic value of the system under discussion, in the handling of coal and ashes, it is of interest, and the table on operating costs gives such values in terms of the cost of a horsepower and also values on the assumption that the cost of a horsepower is $60 a year, 2c an hour. A study of this table shows that the net cost of operation consists of 2 distinct charges, one depending upon both the load carried and the cost of power and the other simply upon the load carried, or capacity of conveyor. This latter expense is that that is entailed in running the apparatus, or empty conveyor, having a capacity of the load carried. That is, these values for the net operating cost depend upon the conveyor being operated at its full capacity, the condition that must exist if the full value of the installation is to be obtained. Furthermore, these values can only be obtained by a frequent, if not continual use, of the system.

CORROSION OF CONDENSER TUBES

TWO important requisites of a good condenser tube are a high coefficient of heat transferred and the ability to resist the corrosive action of cooling water and steam. It is quite evident from the paper presented by George A. Orrock before the A. S. M. E. on The Transmission of Heat and Surface Condensation that corrosion, oxidation, vulcanizing, pitting, etc., reduce the amount of heat transferred. In a test of a badly corroded Admirality tube the coefficient of heat transferred was 0.55, while with a similar new tube it was 0.98, the heat transferred by a copper tube being considered at 1.00.

Condenser tubes of various materials were tested and one of the most interesting of these was the Monel Metal tube that was 1-in. outside diameter, and thickness of No. 18 B. W. G. The results of these tests are found in the accompanying table.

While the coefficient of heat transferred was higher for some other tubes than for the Monel Metal tube, this metal has the advantage of being less corrodible

Heat Transfer Through Monel Metal Condenser Tube
Dry Vacuum Lines Only Slightly Open

Cir. Wtr. Per Hr. Lb.	Stm. Cond. Per Hr. Lb.	Ratio of Wtr. to Stm.	Abs. Pressure in Cond., In. of Mercury.	Temp. of Stm. Deg. F.	Temp. of Inlet Wtr., Deg., F.	Temp. of Outlet Wtr., Deg. F.	Temp. Rise of Wtr. Deg. F.	Arith. Mean Temp. Diff. Deg. Fahr.	B.t.u. Per Sq. Ft. Per Hr. per Deg Mean Temp. Diff.
8925	57.1	156	3.51	119.6	40.58	47.13	6.55	75.7	773
8810	68.2	129	5.01	133.3	40.80	48.68	7.88	88.6	783
8970	91.0	98.5	10.08	161.5	40.80	51.03	10.23	115.6	794
8840	107	82.5	14.96	178.5	40.50	52.5	12.0	132.0	805
8970	128	70.0	22.98	198.1	40.15	54.13	13.98	151.0	830
8810	126	70.0	23.01	198.1	40.0	54.0	14.0	151.1	817

Average velocity of water through tube 8.77 ft. per sec.
Tube 1 in. outside diam. No. 18 B.W.G.

than bronze and has a finish like pure nickel. A tube composed of 2 metals such as copper over an aluminum lining may split owing to its being composed of two layers of metal, but Monel Metal tubes are made in one piece and the metal is produced from the natural ore which contains about 67 per cent nickel, 27 per cent copper, and 6 per cent of other materials.

As an indication of the noncorrosiveness of this metal, might be mentioned the fact that propellers of this metal have been found to offer maximum resistance to corrosion when used for pump linings and superheated fittings.

SEPARATORS AND ENGINE LUBRICATION

Amount of Cylinder Oil Needed and Effect of Water on Oil Consumption

IT is important that the cylinder of an engine be properly lubricated, and water in the cylinder is a hindrance in securing such a condition. Keeping water out is, therefore, most important, and in this connection extracts from a letter by W. M. Davis, given in Cochrane Engineering Leaflet No. 10, issued by the Harrison Safety Boiler Works give much valuable data from experience.

"In this part of the country practically all the cylinder stocks are made from Northern Pennsylvania crude, the flash test always being over 500 deg. F., and from that up to 550 or 560 deg. They would have to be heated above 300 deg. before they would give out any trace of vapor, but this you can easily ascertain for yourself by placing a sample of the oil in a dish over a Bunsen burner with a thermometer suspended in the oil.

In the Western states a great deal of what is called Lima stock is used in making cylinder oils. This oil is made from Ohio and from Western crudes. It usually has a flash test of from 460 to 470 deg. and is not a very good lubricant. Some oil companies use degras in compounding it. This is a very inferior fatty oil used for this purpose. It is not wholly saponifiable, its flash test is but little over 300 deg. It is just possible that this would give off a vapor in the presence of exhaust steam.

"As you prabably know, if the steam cylinder was absolutely dry, a straight petroleum oil would give excellent results as a lubricant, the same way as it does in a gasoline engine or air compressor cylinder, but as the steam is always more or less wet, due to condensation, etc., and as a petroleum oil has no affinity for moisture and will not stick to moist surfaces, it is necessary that some fatty oil be used.

What is known as acidless tallow oil is generally used for this purpose, in fact there is nothing better. It has a flash test of 540 deg., so could not vaporize in the presence of exhaust steam.

The content of fatty oil required varies with the conditions. For an ordinary single cylinder engine where the pipes are well covered and the steam fairly dry, 3 per cent of fatty oil should be sufficient to give good results. For compound engines, from 5 to 6 per cent should be sufficient, although I have known instances where the steam was quite wet and 5 per cent was sufficient for the high-pressure cylinders, but with this amount the low-pressure cylinders were dry, and increasing the content of fatty oil to 10 per cent gave excellent results.

Where the exhaust steam is used for manufacturing purposes, the content of fatty oil should be kept as low as possible. The amount required can easily be determined by experimenting; remove cylinder head and examine the cylinder surfaces, wiping over them with a piece of soft paper, if a good stain of oil is found it is an indication that the lubrication is all right with that amount of fatty oil, and if the steam is dry perhaps this amount can be decreased. But the worst trouble with oil in the exhaust steam is due to the fact that the average engineer uses a great deal more oil than there is any need of, sometimes several times as much.

"I have just finished dictating a letter to the manager of a large works who says that his engineer has to use twice as much cylinder oil as he formerly did. He sent me a sample of the oil and wanted to know if the oil had been changed. When I visited the works a few months ago they were using 2 gal. a day of 9 hr. on a small compound engine. I knew from past experience with lubrication of hundreds of engines that this engine under fairly dry steam conditions and with the oil they were using should not have required more than ½ gal. per day (9 hr.); in fact, I know of a number of engines of greater size and speed running night and day where the consumption amounts to only a quart for 12 hr. and the price paid for the oil is only 21 cents a gallon. In the complaint that has just come to me they were paying over 40 cents a gallon for the oil.

"I know of several single cylinder engines, 24 by 48, making 100 r.p.m., running 11 hr. a day, and the consumption of cylinder oil for all the engines for the whole month average 3 to 4 gal. each or about a pint per day for each cylinder. At one of these plants the content of fatty oil in the cylinder stock is 5 per cent; am not certain as to the other plants. With this amount of oil, the cylinders when opened are always found to be well lubricated.

"On the other hand, I had occasion to inspect lubricating conditions for a large steel works where the consumption of oil in the cylinders was something enormous. In 2 particular engines, both compound, they were using over 500 gal. or nearly 11 bbl. a month in the cylinders of each engine. I have known of many engines of just ordinary size and speed where from 50 to 300 gal. a month were used. If these engines had used a moderate amount, say 12 to 15 gal. a month, there would have been little if any trouble from this cause.

"I note in your letter and I think also in the catalogue that you speak of the need of a separator in the steam line and its importance as regards efficient lubrication and an economical use of cylinder oil. From my past experience in steel works, I have found that where conditions were very bad as regards wet steam, muddy water in the boilers and the steam carrying over with it the mud and water, that the introduction of a separator enabled us to make the most decided reductions in the cylinder oil consumption. In one particular case where the engineers were using 5 and 10 gal. of cylinder oil a day in a vain effort to keep the valve of their Corliss engines quiet, after putting a separator in the steam line so that they had dry steam, less than ½ gal. gave excellent results.

"In regard to the gummy deposit I will say that during the time I was with the Atlantic Refining Co., in Pittsburgh, nearly 11 years, and the 4 years I was oil inspector for the American Sheet and Tin Plate Co., I had occasion to investigate a great many complaints of this kind, and invariably I found the trouble due to 2 things, usually muddy water carrying over from the boilers into the cylinders and as the average engineer uses several times as much oil as he should, this excess amount of oil serves to act as a binder to the sediment and cause it to clog the piston rings and accumulate on the valves and in the valve chambers. While if only enough oil has been used to lubricate the surfaces the earthy matter would have passed out with the exhaust.

The other cause for gummy deposit is due to cut cylinders, these complaints nearly always came from

rolling mills or plants where the engineers had worked in rolling mills, and had acquired the pernicious habit that used to be common among rolling mill engineers of pulling off the cylinder heads every week or so and monkeying with the piston rings and springs and very often getting them so tight as to cause the cutting, and then blame it on the oil. The first named trouble emphasizes the importance of having good separators in the steam lines.

"Trouble from oil working up past the piston of a vertical single-acting engine is usually due to the rings having become so worn that they do not fit the cylinder, or, as is more often the case, to the breaking of the rings. This is another instance of the need of a good separator in the exhaust line."

ECONOMY IN LUBRICATION

General Principles and How It May Be Secured

THE art of economical employment of lubricants consists in the determination of their adaptation to specific purposes, and in the application to each machine—or each part of a machine on which pressure of lubricated surfaces of widely differing amount is found—of precisely that quality of unguent which is best adapted to that particular place, and, above all, in applying it in the best possible way."

In these words Professor Robert H. Thurston laid down the fundamental principle on which the art of lubrication rests:—the fact that "good enough" lubrication is not really good enough, since the only really cheap lubrication is that which is best. But to determine which is the best the question must be studied from various viewpoints.

Starting from the broadest, it is enough to say that on high-speed engines a light-bodied oil usually is to be preferred, because such an oil works more readily into the light, swiftly moving parts. For low-speed, heavy engines, the heavier-bodied oils naturally suggest themselves, because they have more cohesion and, with a better resistance to the natural tendency of the wearing parts to force the lubricant out from between them, they are most effective in separating these moving parts from each other.

The ideal to be aimed at, at all speeds and all pressures, is an oil heavy enough to keep journal and bearing apart, and light enough to avoid friction in the oil itself and to penetrate freely all parts of the wearing surfaces. In other words, full lubrication is got by the thinnest oil that keeps the journal and bearing apart, and this means the oil must be exactly suited to the place and the work.

While it is not always possible to go so far in actual practice, it is not too much to say there is a possible oil for every friction-place that will give more ease, at that place, than any other oil; and the student of economical lubrication will always be on the lookout to find the most suitable oil for any given point of friction. The great fact of practical, everyday importance is that a proper knowledge and use of oils means a highly significant saving of power and operating expenses. It means smaller fuel bills. It means your works are under less strain and you have less deterioration of your machinery, with fewer breakdowns, delays and repairs. It means increased efficiency and larger, better results.

This brings us to another point, often overlooked. Far the greater part of your loss, both of power and by wear, occurs when the friction is making no sign. In the present-day struggle for economy so much attention is devoted to keeping down the cost of developing power that the question of the cost at which it is transmitted is sometimes neglected. The power used by an engine in overcoming the friction of its own wearing parts may range from 3 per cent to as high as 20 per cent of the total power the engine is capable of developing, and it is obvious the latter figure means a most destructive waste, however low the apparent cost of development may be.

A common tendency is to wait for "trouble" to show itself before bothering much about the friction against which the engine is working. For some there is no friction so long as the journals keep cool. The fact is that long before a bearing gets to the "trouble" stage it is wasting much power and wearing out the machinery. The friction that causes a hot bearing has unsuspected preventable friction behind it; and this preventable friction wastes more power and wears machinery vastly more than the friction that shows in heat, because it is working all the time all through the plant. Power is never "lost." The power you speak of as being lost by friction is always busily at work, wearing the bearings and putting an extra load on the engine that has to overcome the friction.

It is Prof. Thurston's estimate that the average friction amounts to 1/10 hp. per bearing. This friction often is taken so much as a matter of course that the engineer hardly stops to think how much is added to his monthly fuel bill by the necessity of furnishing power to overcome it. But multiply this 1/10 hp. by the number of bearings in your engine, and when you remember that a horsepower costs anywhere from $25 to $75 a year, you will readily see the expense of providing the additional power required is many times greater than any saving that can be effected by the use of insufficient or inferior lubricants. The item in which the real saving can be made is in the fuel bill—simply by using the right oil.

There is also the persistent fact that you cannot waste power alone—it takes machinery with it. Thurston gives 2½ per cent of the plant as a fair annual allowance for putting in new machinery, solely for wear, whereas the usual wastes caused by preventable friction can be avoided by high grade lubrication.

Further, it has been shown by actual frictional tests that, aside from the saving in wear and fuel, there is a saving of anywhere between 50 and 100 per cent in actual cost of oils in the smaller qualities of high grade oil used as compared with the much greater amount of poor oils that is required.

"A reduction of 50 per cent in the work lost by friction has often been secured by a change of lubricant," says Thurston. There is as much difference between a well-oiled and an ill-oiled machine as between a good machine and a bad one. True economy in lubrication consists not simply in avoiding "trouble," but in economizing on power and wear before any "trouble" develops.

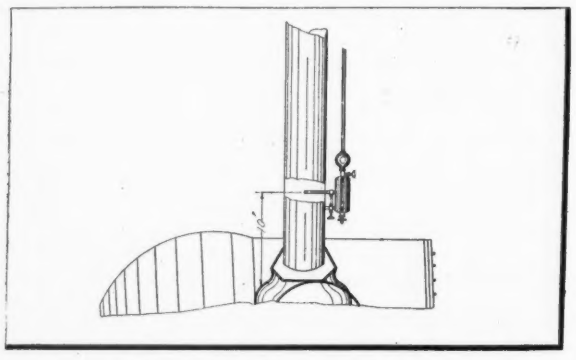
Greases, of course, have their necessary use under special conditions, in places where it is difficult to apply oil, or where oils might fly off.

Petroleum Cylinder Oil has to-day reached a high degree of perfection and is without doubt the most economical and efficient steam cylinder lubricant known. Interesting results were obtained from a series of tests on a slide valve engine driving a dynamo by means of a belt. Indicators showed that, with the load off and the cylinder and all outside wearing parts completely lubricated, 16 hp. were required to overcome the friction of engine and dynamo. During the next 7 hours the engine was operated to its full capacity without any lubricants being admitted to the cylinder or steam chest. At the end of that time the load was thrown off the engine

again, and a series of friction diagrams taken in the same was as before. These diagrams showed that 24 hp. were being used, the additional 8 being required to overcome the friction caused by the absence of proper lubrication in the steam chest and cylinder.

Continuing the experiment, a cylinder stock was admitted to the cylinder for 15 min. at the rate of one drop to every 15 revolutions of the engine. The diagram then showed only 21 hp. were required to overcome the friction. Next a medium grade of cylinder oil was admitted to the cylinder for 15 min. at the rate of one drop to every 40 revolutions, and the horsepower required dropped to 19. Lastly a high grade lubricant was used at the rate of one drop to every 100 revolutions, and at the end of 15 min. the friction was reduced once more to a fraction over 16 hp.

There are 2 points of special interest in connection with this and other similar tests. The first is the difference shown in the efficiency of the lubricating oils used, friction being more effectually overcome by the high



PROPER LOCATION FOR LUBRICATOR AND FEED PIPE

grade oil fed at the rate of one drop to 100 revolutions than by the cheap cylinder stock fed at the rate of one drop to every 15.

The second point to be noted is that, while the diagram showed these marked differences in friction when the engines were operated with or without proper lubrication, it was hard to detect any difference in the actual running of the engines apart from the records given by the indicators. In nearly every case the engines operated as quietly when friction was excessive as when it was being reduced to a minimum. In other words, the fact that an engine operates quietly is far from being proof positive that there is no undue friction.

In admitting oil to the cylinder, the oil pipe leaving the lubricator is sometimes inserted into the steam pipe from 2 to 4 ft. from the cylinder and often projects into the steam pipe only a short distance, ½ or ¾ in. With a very heavy oil better results are often obtained, that is, the oil is broken up and atomized more completely, if the oil pipe could be placed 6 to 10 ft. back from the cylinder and allowed to project into the steam pipe about half of the steam pipe's diameter.

It should be borne in mind that the ideal condition to be secured is to get the steam saturated with oil, so that the steam carries the fine particles of the lubricant to every part of the cylinder. If the oil pipe projects only a short way into the steam pipe some of the oil is apt to trickle back and down the sides of the steam pipe, without getting broken up at all. By making the oil enter the middle of the full body of steam it is quickly broken up, and the fine particles, scattered in every direction, saturate the steam thoroughly and insure complete lubrication.

A further way of helping towards this desired result is to plug up the end of the oil pipe and bore 4 or 5 small holes in one side, the pipe being so placed that the small holes face the same way the steam is flowing. This tends to wipe out the small drops of oil from the feed pipe and also draws the oil from the lubricator more easily. These methods, however, cannot always be recommended where the steam pipe comes to the cylinder as a vertical riser, as the oil has considerable weight compared with the steam, even in its atomized form, and it is possible there would not be enough lifting force to raise the oil.

It is known, of course, that straight petroleum oil will not adhere to a moist metallic surface, and as under ordinary conditions cylinder oils are more or less moist, a small addition of acidless fat is needed in cylinder oil to form an adhesive emulsion. With steam very wet special compounding should be used. Excessive moisture may come from overtaxed or priming boilers or from bad piping. If the piping is long, condensation is sure to be a steady factor to contend with, while short piping may have bends and pockets where the water will collect and come over to the engine at intervals. Overloading of the boilers is also apt to cause excessive moisture, especially if the load is fluctuating.

All these conditions can be materially helped by the use of a proper oil, though in the case of such rudimentary difficulties as boiler priming and condensation, every effort should be made to check the original cause of the trouble.

GRAPHITE ABOUT THE POWER PLANT

By Russell R. Ux.

As a lubricant, the value of graphite became known nearly a century ago, or to be exact about the matter, Rennie in 1829 demonstrated its value as a means of perfect lubrication.

It has been proved that graphite can be used in almost any way necessary, such as feeding it through oil cups, or oil pumps, or placing it directly on the rubbing parts of any kind of machinery.

Quite frequently the inside conditions of their engine cylinders has been brought to the attention of engineers, as in almost all cases they are scored and cut, which causes overheating by an increased friction. It should always be born in mind by the engineer that the cost of lubrication equals the price of the lubricants plus the cost of the friction accompanying their use.

Greases and oils are the 2 best known reducers of friction, but pure graphite possesses certain qualities not possessed by either of those mediums.

Experience has shown me that graphite is the only article which will go directly to the real cause of friction,—microscopic roughness,—and practically perfect the metal surfaces, by filling in the unevenness, thus producing a mirror-like surface.

Efficiency of greases and oils depends in a large measure upon the varying local conditions, such as speed, pressure, temperature and the amount and way they are supplied to the bearing surfaces. An oil which gives apparent satisfaction at a normal temperature becomes too thin at a higher temperature and too viscous or thick and gummy when colder. Similar conditions exist also with changes of speed and pressures.

The perfect condition is, of course, where a lubricant is used of the very least viscosity, sufficient to

keep the metal surfaces apart; but in attempting to do this there is always danger that varying conditions may reduce the viscosity so that oil cannot support the load, and then consequent cutting and heating result.

This danger is entirely eliminated when graphite is used in connection with oil or grease as surface to surface contact is unlikely when the thin graphite coating is formed.

As a cylinder lubricant graphite is coming into more and more common use either with oil or alone. It completely fills up small holes and sometimes very small cracks, apparent in cast-iron cylinders.

When water happens to come in from the boiler or other source and washes the cylinder oil away, or if from defects in oiling appliance the cylinder commences to groan, as it quite frequently does, regardless of close attention and care, graphite will instantly stop groaning if fed with a little oil through the hand pumps.

Graphite reduces considerably the amount of cylinder oil required for given conditions of service; this is generally noticeable in the better behavior of the engine, easier handling of the valve gearing and last but not least, the indicator cards which will show it most effectually.

The objection raised against graphite as a cylinder lubricant is the supposed inability to eliminate it from the exhaust steam which is quite frequently used for a score of purposes.

This objection is generally raised by men not conversant with the use of graphite for this purpose; for any eliminator, settling tank or skimmer that takes out a fair percentange of the oil will positively remove all graphite.

I have known a fireman who had charge of a large number of return tubular boilers to put into each drum after cleaning, one large handful of graphite, which he claimed made it easier to clean the tubes and surfaces of the boiler inside. He also proved it, for by simply tapping the boiler shell with a hammer the scale fell off and the graphite was very noticeable in small particles on the scale where it adhered to the iron.

Graphite can be used on pipe threads to great advantage, as it allows the pipes and fittings to be disassembled after long use without breaking or squeezing out of shape. It is equally useful for the threads of flange bolts, valve stems, packing, etc.

When put up with linseed oil and other oils for painting purposes, I have known graphite to give most excellent results on stacks and boiler fronts.

LUBRICATING EXPERIENCES

Grease Versus Oil

By F. M. N.

IN the cotton seed oil industry steady running is of prime importance towards good manufacturing. I early discovered that clean machinery plays no mean part in keeping the mill up to the scratch, and making the seasons crush without loss of time, due to breakdowns. Working in line with the above, I have dispensed with oil as a lubricant wherever possible or where it would collect dust and lint on the bearings. After trying out different greases in spring and hand compression cups on various machines, the best results were obtained from a soft grease that would not flow or change its density under any heat that the bearings would stand, by fitting the cups so that the grease could be forced to the spot needed and not depending on the bearings warming up to supply lubricant.

In one machine we force grease through about 4 ft. of ⅜-in. pipe with a plain steel hand compression cup. To facilitate this a piece of ⅛ by 1-in. iron was riveted to top of cup so as to give a better grip on it. This suggests the idea of dropping a pipe with cup attached from shaft bearings or bearings of any kind that are just out of reach from floor or platform.

Change from oil to grease was very satisfactory on this mill engine, a 16 by 42-in. Atlas Corliss, 100 r. p. m. Due to lint and dust, this engine would look like a woolly sheep at the end of a week's run, 24 hours a day. The flying dust would collect wherever there was oil on exposed surfaces, forming dirt that could not be blown off but must be wiped off. I fitted this engine with one 3-oz. spring cup on the wrist pin, one 4½-oz. spring cup on crank brass, hand compression cups on bearings, eccentrics and top and bottom guides, also on rocker shaft, wrist plate, and governor bearings.

We ran this engine last season equipped as above for 6 consecutive months, 24 hr. a day, 137 hr. a week, with a loss in the mill of less than 2 hr. working time for the season; and this shut-down was not due to engine failure.

The 3-oz. and 4½-oz. cups on wrist pin and crank were filled once a week; the other cups could be filled while running and were not fed as steadily as the spring cups would feed, but were usually filled every fourth day. I had some trouble at first with spring cups failing to feed when half empty the latter part of a week's run, and could not overcome this trouble with the ordinary spring compression cups.

I ordered 2 cups that did away with the trouble from the France Packing Co., Philadelphia, Pa., made with the cup body threaded inside and sleeve carrying plunger and cup leather threaded to screw into body by hand as the cups were emptied of grease, thereby keeping a uniform tension on the spring.

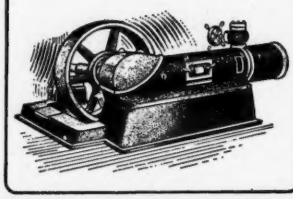
We would screw these sleeves in about 1 or 2 turns every morning, as we made it a practice to stop the engine for a short period while the night and day shifts were changing. The engine ran through the season without bearing trouble, was kept very clean and the grease was not wasted as the oil had been. also in line of economy 1 lb. of grease at 15c would do the work of 2 or 3 or even 4 gal. of oil at 20c a gallon, and on some bearings in the mill that were attended to by negroes the change to grease stopped considerable waste.

This season the mill is being driven by a bituminous gas plant, a 3-cylinder vertical gas engine installed by the side of the old Corliss, and this new comer is just as steadily on the job as the other.

RUMOR HAS BEEN CIRCULATED in some quarters that the works of the Platt Iron Works Co., are closed. This is without foundation as trustees have been elected by a society of creditors of the company and these trustees are now in charge of the property with full authority to conduct and carry on the business. The entire manufacturing and selling organizations are intact and the plant is being operated on regular time, requiring upwards of 750 employes to carry on the work. Special effort is being put forth to give the very best possible service in the repair department as well as in the departments devoted to the manufacture of new apparatus.

Letters from Engineers

Bright Ideas direct from the plant. Send us yours. Cash paid for those accepted. Sketches desirable; we make the drawings

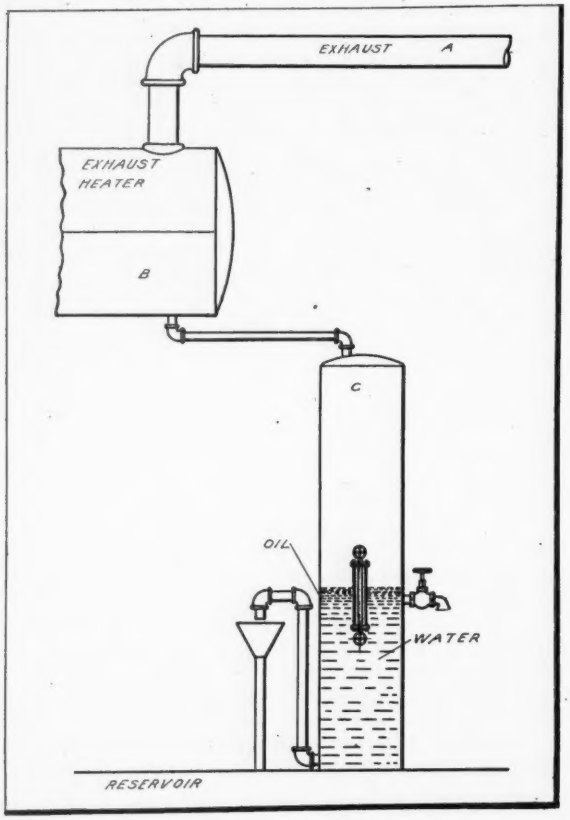


HOME-MADE OIL SAVER

WITH a few words of explanation, I think the accompanying drawing can be readily understood by almost anyone about a power plant. It is an oil saver by name, and (what is more to its credit) by nature too. It will pay for itself in a little while, if you are as fortunate as I was in getting the material with which to make it. The only outlay of money I made was for a glass water gage and attachments, $1.50, and one old water heater of the junk man, 25 cts.; the rest, a few little pipe fittings, are always to be found lying around waiting to be used. But even if you had to buy these few fittings, it would yet be money well spent.

I will say first, this is just a small wood-working plant equipped with a 50-hp. steam engine. This engine exhausts into a drum B, which contains a coil of pipe that is a part of the feed water line from pump to boiler. The exhaust A therefore carries off more or less water and with it is oil from the engine. This water is carried from the heater B into the old water heater, where it is drained by making the connections as shown, by which arrangement there is always the same amount of water in tank C whether the engine is running or not, and also it does not require any extra attention, only about once a week to draw the oil which accumulates on top of the water in tank, which on trial in my case was 1 gal. the first week I had it in operation. The water also runs back in the reservoir and is used again, making still another saving where city water is used.

Frank Baum.



ARRANGEMENT FOR SAVING CYLINDER OIL

CURING A FEED PIPE POUND

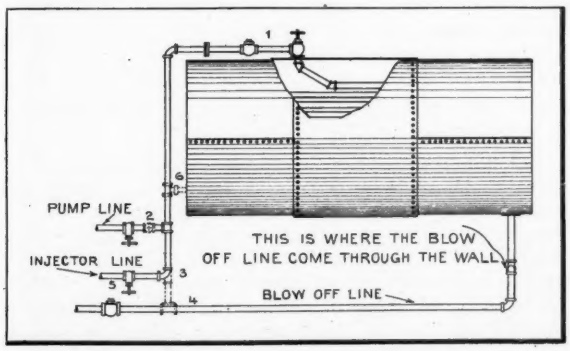
SOME time ago I took charge of a new plant consisting of one 250-hp. tubular boiler and two engines direct connected to generators. The feeders for the boiler consisted of one injector and one duplex pump. After looking the plant over, I put water in the boiler and started up. I used the injector for about 2 weeks before the pump was ready for use. In the meantime part of the factory was put in operation and as we had an open feed-water heater, I wanted to get the pump going so as to get some benefit from the exhaust steam, as the engines were run noncondensing. So as soon as the pump was ready, I put it in operation, but the noise in the feed line was like a boiler factory working over time with the pump in use, although the injector worked smoothly at all times. The contractors wanted the pump kept going to see if they could locate the trouble, so I kept the pump going, as the place was in the contractors' hands.

The drawing will show the way the feed line was connected in the top of the boiler. After running with the pump for 2 days the bonnet of the angle valve blew clear off at about 10 a. m., shutting the place down, and, as is usual in such cases of accidents, no contractors' men were on the job; so as soon as the steam was low enough to work with it, I put an ell where the angle valve had been and a straightway valve at the place marked 1. At 1 p. m. I was ready to start the engine again, having turned more steam on the building and kept the engine running as long as I could to get rid of the steam, I still had 4 lb. of steam on the boiler when the job was finished; about this time the contractor showed up and he still insisted on running the pump, so the pump was put in use again with the same pounding in the feed line. The next day the bonnet blew off the straightway valve, causing another shut down besides scaring the employees so that they were afraid for weeks afterwards to be in the building, as they thought the boiler itself would go up next.

As the second shut down happened about 4 p. m., I had more time in which to do the job, as the factory ran only days. The contractors' men being on the job this time, they put in an extra heavy valve at the place marked 1 where I had put an ordinary valve before. The result was there was a conference the next day and I was called on for my opinion. I told them I was opposed to having a feed line in the top of the boiler, at least in the way this one was connected, as I claimed no pump running at the speed ours was would keep the feed

line full of water in the boiler and when the feed line was partly empty in the boiler it would fill with steam, causing a fearful water hammer. They would not believe that was the cause here, but at the close of the conference I had my way.

That night I made the changes as indicated at 2, 3, 4 and 5; instead of feeding into the top of the boiler I fed into the blowoff line and continued to use the pump, and there was no more trouble. I took the job with the understanding no cure no pay, the contractor supplying the material, and when he saw the result he paid with a smile on his face, saying he was



PIPING WHICH GAVE TROUBLE AND THE REMEDY

well satisfied with the job and the results. I was going to make a connection as shown at 6, when I would have had 3 feeds to the boiler; even if one was not much good, it might have held over for some emergency; but I got a job at another place with more salary, so I did not make the change, though I recommended it to the man who took my place. Another advantage is that the blowoff valve is in front of the boiler now as indicated at 5.

John Mitchell.

PURGING CARBON DIOXIDE SYSTEMS

I HAVE been a reader of Practical Engineer for some time and have read with great interest subjects upon the ammonia systems, that is, the many different kinds of ammonia systems, care and operations, and also the different ways of purging them, which have been of great help to me. As I have had 8 years experience in carbon dioxide systems of refrigeration and the ammonia system is a new thing to me, I have been working with it only 6 months, and there probably are some readers carbon dioxide men, I would like to hear from them on this system with the idea that I might be able to help the mout on some things.

To start a discussion, I would like to ask the question: what becomes of the air in the carbon dioxide system, for instance after a man has had a leak in one of his rooms and has pumped back all the liquid and has had the pipes apart and repaired the leak, what has become of the air that went in the pipes; is it squeezed up in a corner some where, or where is it? There is no means that I know of provided for purging that kind of a system.

Engineers in the carbon dioxide systems don't know what purging means, I have never seen one purged in my 8 years' experience with the carbonic system. One engineer told me that his cold storage had been running 12 years and he never purged the system of air or foul gases, in fact he never heard of the purging. That's why I speak of this, as the ammonia systems have purge valves and the engineer can free the pipes of foul air or gases at any time he sees it's needed. I would like to hear from some brother engineer on the soubject.

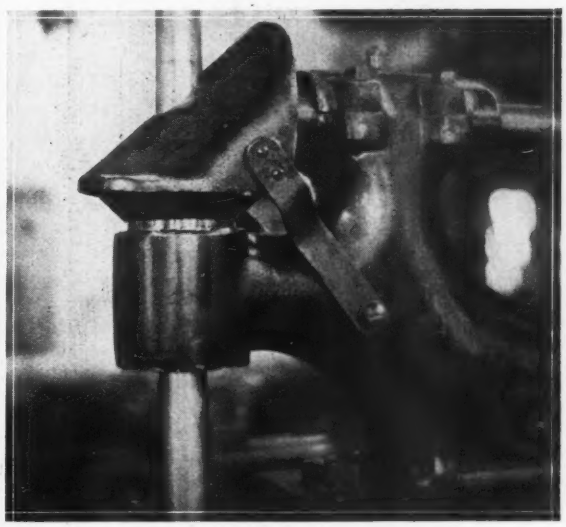
Martin McGerry.

SHIELD FOR BEVEL GEARS

BECAUSE of the rigid enforcement of numerous employers' liability laws, a great deal of interest has been manifested by owners and those in charge of machine shops, in safely covering the various moving and dangerous parts of exposed machinery.

Bevel gears are perhaps the most difficult to cover, because of protruding shafts and the unsightly appearance that the average bunglesome shield lends to the general aspect of the machine.

The accompanying cut shows perhaps the neatest, cheapest and most suitable shield that can be used for protecting a workman from dangerous bevel gears. The body casting of the machine can easily be drilled and tapped for a small cap screw of sufficient size to hold securely a moderately heavy shield of this nature.



SHIELD FOR BEVEL GEARS

The shield affords a positively safe protection for the hands and fingers of the workman, as well as protecting the gears themselves from other matter that often gets into the meshes of the teeth from other sources.

F. W. Bentley, Jr.

RAISING SMOKE STACKS

HAVING had a number of set-tos at the game of raising smoke stacks, I can imagine seeing C. R. McGahey, or his under study following directions given in the December issue of Practical Engineer, after a successful raising, climbing to the height of about 75 ft. to release the tackle block and sling from around a stack 60-in. diam. by perhaps 80 ft. long set on a brick base 30 ft. high. If he performed that little stunt without making the ascent he failed to tell his readers about the most interesting part of the whole performance. There is nothing new about it and I lay no claim to having been the discoverer of this release hitch, yet I have never seen it illustrated.

In the illustration A shows the sling around the stack, tackle block in position while the stack is raised, with the release line hitch properly made with free end long enough to come within reach from the base of the

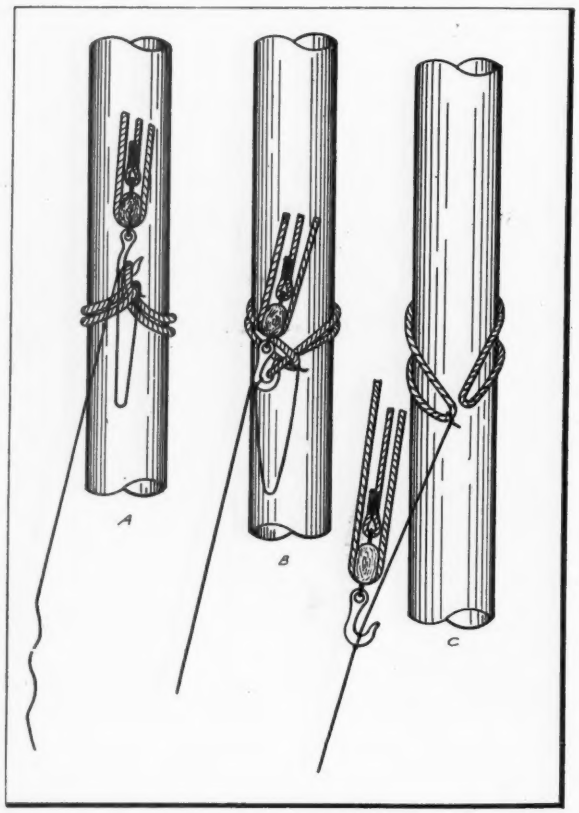
stack, B shows the act of releasing the hook from the sling by pulling down on the release line, C shows the hook released and by continuing to pull down, the sling is removed from the stack.

E. H. Sonneman.

BOILER GAGE PRECAUTIONS? DRY KILNS

SOMETIMES the question is asked, "Why do boilers explode?" A great many cases are mysteries and always will be.

But there are preventable cases. There are times when we ask, "Why don't boilers explode?" I was



RELEASING HITCH FROM STACK

employed for about a year in one plant of 500 hp. where there were 2 250-hp. water-tube boilers. They were supposed to pop at 140 lb. gage, when both boilers were in operation and connected together one gage would show 135 lb., the other one 145 lb., and the engine room gage 140 lb. when the valve on No. 2 would let go. The valve on No. 1 never opened, when I asked the chief about it he said that they used to have trouble with that valve leaking, so he screwed it down tight and let it corrode till it stopped.

Sometimes we would cut out No. 2 and run No. 1. I asked him what should be done then if the gage went wrong. "Well," he said, "we'll run by the engine room gage." A nice thing indeed for the fireman, the engine room was around behind the boiler and upstairs. One day that gage did go wrong. I was around behind the boiler and when I came back the pointer was down to zero; 3 min. before I had 125 lb. on it. The other boiler was cold. I looked at that gage till my eyes burned, then I looked at the boiler room door, then I grabbed the fire hoe, dropped that and hotfooted upstairs and looked at that gage; up there it showed 135 lb. I drew a long breath, told the chief and went back to work. In a day or two the boiler inspector came around. The chief told him about the gage; we took it down, the inspector looked at it and found that the pointer was loose on its pin. We fixed it on, so that it would set against the stop snugly and we put it back. "I guess that's about right; you will see when you raise steam and get them both connected, how much it is out," was the cheering word from the inspector. He never tested that gage or the pop valve on either boiler while I was there, and he represents one of the largest boiler insurance companies in the United States.

At the plant where I am at present they burn about 500 tons of coal a year or its equivalent in wood and shavings. In reality it's about half and half; the plant is in a lumber mill.

The method of feeding is with an injector. This plant has been in operation 12 years, and during that time, buying 320 to 380 tons of coal per year besides burning an amount of wood and shavings that will at least equal a like amount of coal. The water here during the summer reaches a temperature of about 70 degrees. During November it reached a temperature of 42 deg. I think we may safely assume an average temperature for the year of about 56 deg., though it is likely to be colder, rather than warmer than that. The day I went to work for the company I began talking pump and heater. It was about 2 months before I could get them to listen at all.

Then one day I ran a short test just to determine the amount of coal burned daily. I found that with the water at 56 deg. and about one third of the machines on, our coal consumption was 4800 lb. per day. This means about 720 tons a year. With a good open heater that will heat the water to 208 deg. there will be a saving of about 13.8 per cent of the fuel, because for every 11 deg. raise in feed water temperature there is a saving of 1 per cent of fuel. Now if one-half the fuel is wood, that means we would make it do the work of 360 plus 13.8 per cent or 410 tons of coal. The difference between 720 and 410 is 310. A further saving of 13.8 per cent would amount to 42.8 tons on 310 tons, leaving a net amount of 257 tons to buy, a total saving of 103 tons of coal in round numbers. I showed these figures to the manager and he immediately got busy, and we are going to get that heater.

Just think what this company has lost in 12 yr., because "that stuff will cost us $300 or more."

I was somewhat interested in the description of those drykilns in previous numbers of Practical Engineer, and am impelled to ask a few questions myself.

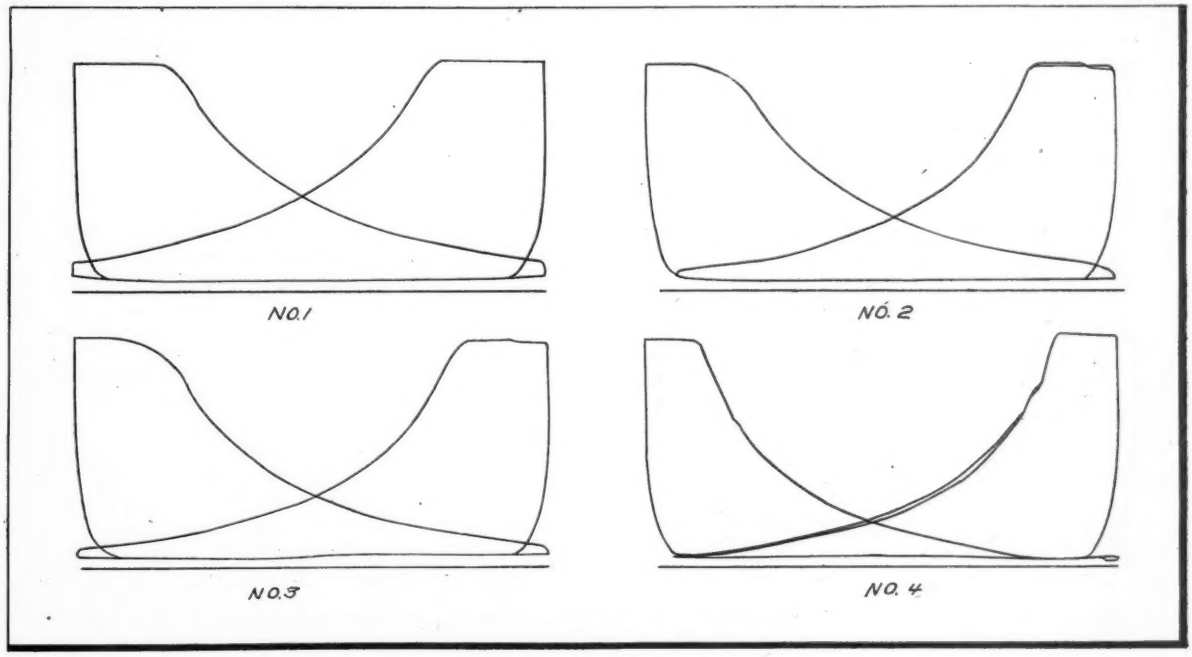
We have 2 kilns here and can not get proper results from one. The exhaust goes straight through both kilns and while the second kiln is only about ½ the size of No. 1 (it has 2200 cu. ft.), it does not get as hot by 30 deg. The only ventilation for it is through cracks and a door that does not fit very closely. The coils are 15 1¼-in. pipes, 20 ft. long, and well drained, there is room for 14 more in the heater. These coils come straight through from No. 1 kiln where they are about 22 ft. long. I would like some one who has experience in this matter to advise me how conditions may be improved, and what arrangement should be made for ventilation. Should ventilators be near the floor or the roof?

H. S.

GOOD CARDS AFTER LONG SERVICE

ACCOMPANYING cards were taken from a Harris Corliss engine which has been running 25 yr. No. 1 was taken with full load on; before No. 2 was taken a little compression was added to the crank end, the cutoff equalized, part of the load being off, and No. 3 was then taken, which does not show the jog in the steam line quite as much. No. 4 was then taken with the working load without the generator on. I can not account for the jog in the steam line on Nos. 2, 3 and 4, and would be pleased to know the opinion of any reader.

C. W. Bennett.



CARDS FROM A 25-YR. OLD

DAMPER REGULATION

WHILE visiting different engine and boiler rooms it has become quite a surprise to me to note how many are lacking the installation of some good kind of a damper regulator outfit, or if in possession of such an outfit to find it out of order and the regulation being done by hand. Then again, there are some owners of steam plants that cannot be made to realize the importance of that instrument or the saving in fuel that can be effected by its use in governing the action of the fire under the boiler, thus keeping it within the prescribed limits, checking the over-consumption of fuel and thereby making a saving by keeping the steam at a more constant pressure. No boiler can be fired and the draft regulated by hand as well as by automatic regulation.

When a damper regulator is found not in use owing to being out of repair the responsibility of lack of economy is brought squarely up to the engineer for allowing it to remain in this condition. The question of not having an outfit is often due to the engineer's lack of putting it up to his employer in a suitable manner, giving the necessary information by figures and data of saving that can be effected by the use of such an instrument. If so explained in 9 cases out of 10 the outfit would be secured.

An opinion is often advanced that the saving in fuel will not warrant the outlay in first cost. Steam is a vapor, the result of the absorption of heat by water, and is capable of being reduced to its original form by condensation, the result being the freeing of the heat, which passes away and is lost, leaving water. Applying this theory to the steam pressure in the boilers it is plainly shown that all steam generated over the amount necessary to maintain the pressure necessary to perform the work is waste. No matter if the work is power, heating, or any other use, there has been consumed a certain amount of extra fuel to produce the extra amount of heat necessary to produce the higher steam pressure. Again, when operated by hand, if the steam should fall below the required pressure due either to neglect in the system of firing or leaving the damper closed too long, extra effort must be made to bring the pressure up again. Either the damper is opened full, causing a sudden strong draft and a rapid consumption of fuel, thereby increasing the temperature of the gases in the stack, or more fuel must be put on the fire, making a still greater waste for the reason that almost double the amount must be consumed in order to attain the result of an even pressure again.

If the pressure is kept constant at a certain figure the consumption of fuel will be only that which is necessary to maintain it. Then again there is the injury to the boiler by the frequent opening of the fire doors, admitting large quantities of cold air, lowering the temperature and producing unequal contraction of the boiler, especially so in the tubes or flues through which this cold air passes, thus bringing extra strain on the tube sheet. By the use of a damper regulator the fires are held in a more even condition. There is no need or necessity of sudden checks being placed on the fire, or any need of pushing it to regain lost ground. The opening and closing of the damper is regular and is done gradually at the time needed, not allowing the fire to obtain a big start before any means are taken

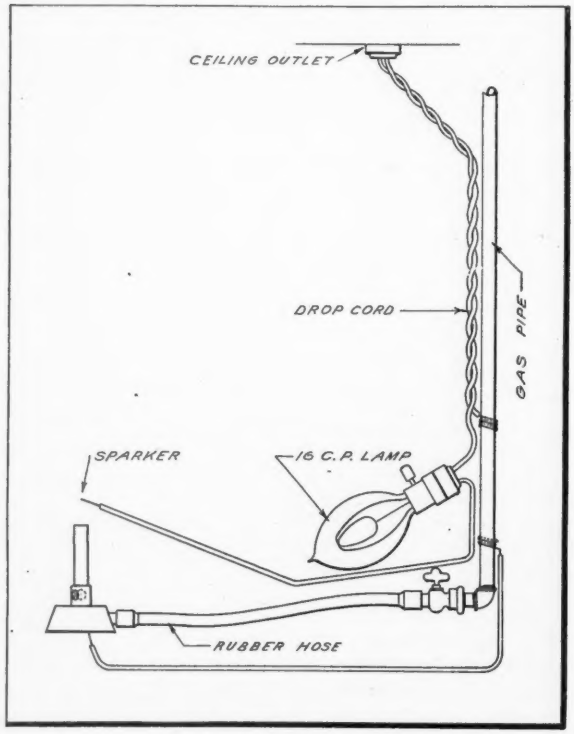
to check it. No one would think to employ the services of a man to stand at the throttle of an engine and open or close the valve as the engine needed more or less steam and expect to obtain the same amount of efficiency in power that he would gain by the use of an automatic engine.

A fireman may have the very best intentions and wish to do his duty faithfully, but he cannot stand all day with his hand on the damper string and his eye on the steam gage and attend to his other work, neither is it possible for him by this means to regulate his fire as closely as it can be done by an automatic machine.

The whole thing can be answered thus: Procure a damper regulator and keep it in working order, (don't hang it up on the wall as useless), for the closer the regulation to procure an even pressure of steam the greater will be the saving in the amount of fuel consumed and consequently the greater the economy in running the plant. Chas. H. Taylor.

HOME-MADE GAS LIGHTER

IN the accompanying sketch I have shown the connections I use in lighting gas burners. Using a drop cord from a ceiling outlet I solder one wire to the gas pipe and the other to a 16 c.p. lamp.* The other lamp wire is soldered to a No. 10 wire which is used as a contact maker. By striking the wire against the burner a spark is produced which will light the gas.



HOME-MADE GAS LIGHTER

In case a rubber hose connects the burner to the gas pipe it is necessary to connect the burner to the pipe by an extra wire as shown in the sketch.

This method is most convenient in lighting gas furnaces under boilers and I employ it on all our furnaces. E. C. Williams.

*Fire underwriters in cities would condemn connection to gas pipe. Editor.

HANDY REAMER; BOILER FEED PUMP TROUBLE

AT one time I was sent out to put up a sawmill; the main shaft, which is 3 in. in diameter was coming from one place and the pulleys from another. When I got ready to put the pulleys on the shaft, I found the shaft was too large or boring too small, there was about 1/32 in. difference. To file out the boring of half a dozen pulleys with a hub about 18 in. long, was not a small job, and the nearest machine shop was 60 miles away.

A half-round and a flat file were all the tools that were available. Looking around the camp I found a round piece of oak wood about 3¾ in. in diameter and

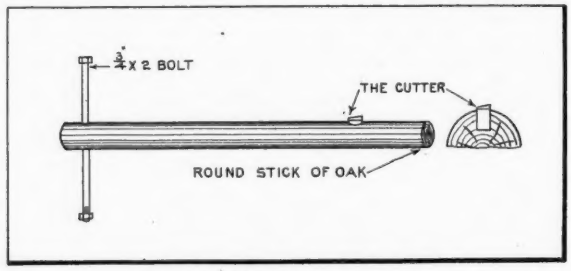


FIG. 1. HOME-MADE REAMER

3 ft. long; I cut it down with a plane so as to fit the boring of the pulley; this was to be the reamer. I put the flat file in the fire, cut a piece off, annealed and filed one edge down to make it like a cutter, then tempered it very hard on the edge.

I cut in the wooden mandrel a grove ¼ by ¾ in. and 1½ in. long so as to hold the "cutter"; a ¾-in. bolt 2 ft. long was used as the handle; after each cut I had to put a piece of heavy paper on the mandrel to

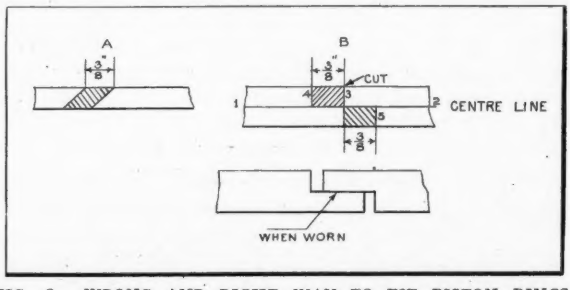


FIG. 2. WRONG AND RIGHT WAY TO FIT PISTON RINGS

make up for cut. In 2½ hr. all were reamed out and true. This is a handy and cheap reamer that can be made to any size.

The other day I was called to fix a boiler feed pump which refused to give its full stroke. They told me that everything in the steam and water valves was alright; they had the whole pump apart three times and the result was same as before, short stroke.

I took the valves' tops off to see how they were; they were in good shape. I took the steam pistons and the rings out and I saw that the rings were so worn out that the steam could pass through very easily. This pump was the only one in the plant and, of course, needed. Chicago is too far from Arizona to send for new rings in an emergency; to use the old rings would not remedy the trouble. I took ⅜-in. square Garlock packing and packed the piston groves very tight and put the pump together again. All being well oiled, the pump went like new and those "piston rings" kept good over a month without renewing.

In repair work, when making new piston rings, it is a custom to make them ⅛ in. in diameter larger than the bore of the cylinder and afterwards to cut ⅜ in. off. Many machinists believe that it is quicker and just as good to fit the rings as at A Fig. 2, but that kind will leak in a short time.

A half and half cut as at B takes no longer to make, and if the ring wears, it is not liable to let steam pass. To make this kind of ring, first, with the dividers or the surface gage draw a line, 1—2 in the middle of the ring, then cut the ring through line 3 with the hacksaw, open the dividers ⅜ in. and mark lines 4 and 5, file down the hatched parts to the line 1—2. If correctly done, the ring will fit and never leak. Chas. Labbe.

CHANGING ENGINE SPEED

IN Mr. Swingle's article, "Steam Engine Governors," in the January 1st issue, there is one statement under the sub-heading "changing the speed of an engine," that seems to me to have unintentionally escaped the author's attention. It is this:

"Second, by adding weight either to the counterpoise, if the governor is of the loaded type, such as the Porter-Allen, or the balls might be replaced by heavier ones." Theoretically, changing the weight of the balls of an engine flyball governor will not effect the speed of the engine to which it is attached. The reason for this is, that when the weight of the balls would be increased, the centrifugal force will also be increased as well as the force due to gravity. Of course it is true, that purely theoretical reasoning must be modified when it is applied in actual practice, and for that reason, placing heavier balls on the governor may cause an unlooked for result. I have never tried the experiment and therefore am not fully qualified to pass upon the statement in Mr. Swingle's article. But, I am of the opinion that with a reasonable change of weight—assuming that the balls as at first designed are correct as to weight for the work the governor has to do, there will not be any change of speed of the engine, as long as the pulley is not changed. Only about a week ago I received a letter from an engineer on this very same subject, in which he said that he had tried placing heavier balls on the governor of his engine, and he found that the engine slowed down. I infer from Mr. Swingle's statement that heavier balls will cause the engine to speed up, for he first refers to placing a heavier counterpoise weight on the Porter-Allen type of governor, which will increase the speed, and in the same sentence advises heavier balls for the ordinary flyball, pendulum governor. One man says the engine will speed up with heavier governor balls, the other, to whom I have referred, says the engine slowed down with heavier balls. Which is right?

It seems to me, from merely reasoning the thing out, and without having actually tried it out in practice, that by placing heavier balls on a governor we would have a more powerful governor, and one in which the range of speed variation of the engine would be less than with lighter balls, the governor speed being the same in both cases. But I do not see how the speed of the engine could be changed by so doing. If either a too heavy or a too light weight be given the balls—out of reason, I mean—then the governor would cease to be any good at all, and probably would "hunt," as we say, and so cause a variable speed.

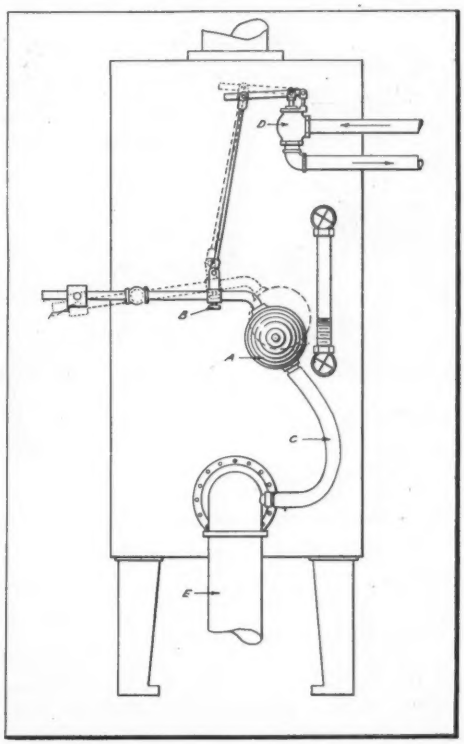
What do other readers have to say about this problem? Charles J. Mason.

A VISIBLE FLOAT FOR OPEN HEATER

AS all of us know, a float inside of a feed-water heater is always giving trouble, and more so when using back pressure, for as the pressure varies the float will jump up and down, which gives poor regulation, and the float is hard to keep from getting water logged. I changed the float on a 400-hp. open heater in the manner shown by the drawing.

A is the old float; B, ½-in. pipe and fittings connected to the heater where the old stem came through, the pipe is open to the inside of heater and float; C is a ½-in. hose which connects the float to the bottom of heater or to suction of boiler feed pumps, as in the drawing. D is either the steam line to pump if using a pump to supply water to heater, or if not it can be the water supply valve. E is the suction to the boiler feed pump.

The water rises in the heater and fills the float and it becomes heavier than the weight F and, as the



VISIBLE FLOAT CONTROL FOR OPEN HEATER

heavy lines show, it closes the supply valve. As the water is pumped out the float is emptied and the weight F becomes heavier than the empty float, and opens the supply valve as shown by dotted lines.

The float can be made the same way for controlling the over flow by reversing the supply connection so that when the float is full or down the over flow is open instead of closed. The pressure in the heater has no effect on the regulation, and the trouble with the water logged float is eliminated.

W. A. Jones.

SOME MEN'S IDEA of close buying is to secure a rebate. Of course the seller usually meets this simply by quoting an original price which gives room for reduction. The man who buys purely for value received averages the best in the long run.—Mahin Messenger.

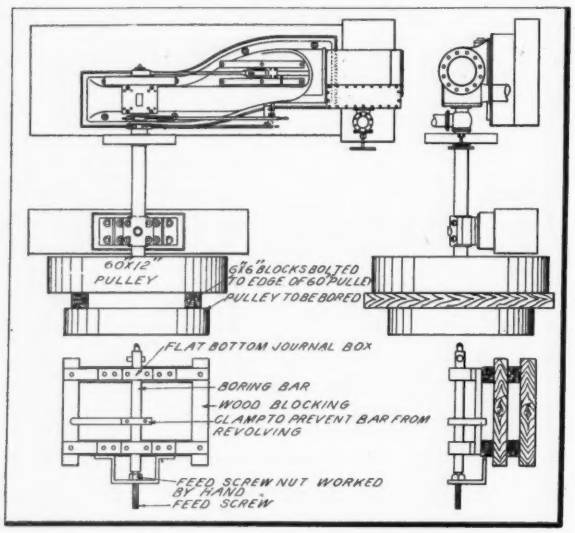
SUCCESSFUL KINKS

FOR SAVING TIME WORK AND TROUBLE

Boring Mill

HAVING just completed remodeling a large factory, during the course of repairs, we found it necessary to increase the size of some of the line shafting which necessitated the reboring of several pulleys. Finding no mill or lathe in the town, large enough to swing them, to save time and expense of shipping them to a machine shop, we concluded to do the work ourselves, the accompanying sketch will show how the work was accomplished.

The wheels to be bored out must be made to run perfectly true, both on edge and face. The boring bar must be lined up perfectly level and at right angles to the work; in this case we lined the bar with a line


60 1/2" PULLEY
6"x6" BLOCKS BOLTED TO EDGE OF 60" PULLEY
PULLEY TO BE BORED
FLAT BOTTOM JOURNAL BOX
BORING BAR
WOOD BLOCKING
CLAMP TO PREVENT BAR FROM REVOLVING
FEED SCREW NUT WORKED BY HAND
FEED SCREW

PLAN AND ELEVATION OF BORING MILL

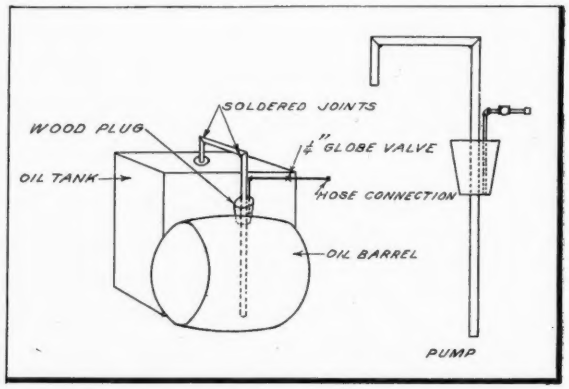
parallel to the engine shaft. A ratchet feed could be rigged up at a small cost, to take the place of hand feed on present rig.

We used an ordinary hook bolt for clamping the work to be bored out to wood blocks, which in turn were bolted to the driving pulley of an engine. We bored out several large pulleys and sprocket wheels, ranging in diameter from 10 to 72 in. The work was finished in a short time and was a good job. It did not cost one-third what it would have cost had we sent them away. The speed of engine was regulated to suit conditions. J. W. S.

Convenient Barrel Pump

HEREWITH is a sketch showing a pump for getting oil or other material out of a barrel into a tank. I made this myself and it may help others in their work. Anyone can make it who can use tools.

I used 1-in. brass tubing, cutting joints to fit and soldering them. A hardwood block 4 in. long was worked out to drive into the bunghole; through this a 1-in. hole was bored for the pump and another hole for the ¼-in. pipe to carry compressed air. We have in the plant compressed air for cleaning generators, and when we wish to empty a barrel I knock out the bung, drive in the wood plug, couple on the air hose, crack the ¼-in. valve a little, and in 5 min. the barrel will be empty and without a drop of oil on the floor.

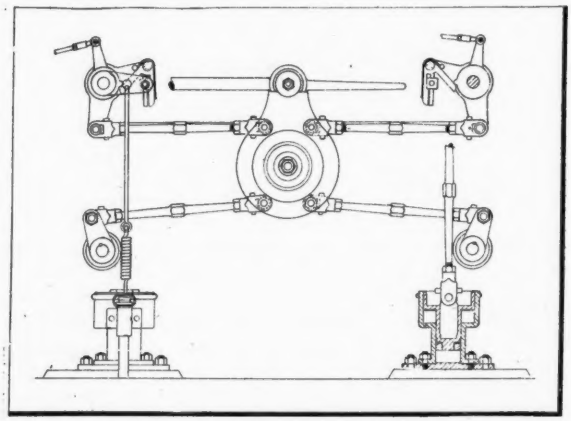


METHOD OF EMPTYING BARREL

The brass tubing for my outfit was taken from an old chandelier. A. W. Jones.

In Place of a Dashpot Rod

THE dashpot rod on a Corliss engine broke, and not having a new one in stock, I kept the engine running in this manner for a week. The rod was removed and a wire 3/16 in. in diameter, of the proper length, was connected in its place. A spring 6 in. long was connected at the lower end to one of the air valves



EMERGENCY DASHPOT ROD

on the dashpot, and by adjusting the spring to the required tension it closed the valve satisfactorily until the new rod was obtained.

Martin McGerry.

Rule for Steam Temperature

IN the absence of a steam table, I have found the following rule quite accurate for obtaining the temperature of saturated steam at pressures between 50 and 100 lb. Multiply the square root of the gage pressure by 14, add 199, the sum is the temperature.

Albert H. Goff.

EUROPEAN POWER PLANT PRACTICE

Utilization of Exhaust Steam; Foreign Method of Heating Without Impairment of Vacuum

By Francis G. Wichware

PAUL KOCHTE, in a recent issue of Der Praktische Maschinen-Konstrukteur, describes a practical solution of the problem of utilizing the exhaust steam of a condensing engine for heating purposes without impairment of vacuum or increase of steam consumption. A textile mill of moderate size required about 270,000 calories (1,070,000 B.t.u.) per hour to maintain a mean temperature of 59 deg. F. with the thermometer at 5 deg. below zero F. Power was supplied by a simple condensing engine of about 120 hp. In the exhaust pipe between the engine cylinder and the condenser, an air heater was installed, similar in design to a surface condenser. The air to be heated was drawn by a fan through small steel tubes surrounded by a bath of exhaust steam, and also through the space between the double walls of the heater, into a main delivery pipe, whence the heated air was distributed throughout the plant. To preserve the necessary degree of humidity for the spinning process, a certain amount of live steam was admitted to the delivery pipe. The installation of the air heater improved the condenser vacuum from 22 or 24 in. to 26 or 26.8 in., and resulted, further, in a not inconsiderable saving of coal.

In cases where a high temperature is required, the heat available in the exhaust steam may not be adequate to supply the demands of the heating plant. Under these conditions the vacuum may be reduced, the engine may be run noncondensing during periods of extraordinary demand, or live steam may be taken from the boiler to supplement the engine exhaust. It is sometimes possible to supply the required amount of heat without recourse to these uneconomical methods by utilizing the exhaust of an auxiliary machine. In a case described by Herr Kochte, 2 groups of buildings of a large factory situated on opposite sides of a river required for heating purposes a total of 6,944,000 B. t. u. per hour. The supply of exhaust steam from the engine was sufficient to maintain the temperature of 57 deg. F. prescribed for the greater part of the plant, but not the temperature of 75 deg. F. required in a few rooms situated at a considerable distance from the power house. The plan adopted to supply the deficiency was to install in the air pipe leading to these special rooms an air heater with a heating surface of 8610 sq. ft., supplied with the exhaust of a boiler feed pump. By this means the temperature of the air was raised to about 154 deg. F. In this case also the installation of the air heater was followed by an improvement in condenser vacuum.

Any method of utilizing the heat of exhaust steam which involves reduction of the section of the connection between engine cylinder and condenser reacts very unfavorably on the steam consumption of the engine, unless the capacity of the air pump is proportionately increased. In an air heater of the surface-condenser type, the slight increase in the length of the steam travel between cylinder and condenser is more than offset by the reduced friction of the larger section. The increase of vacuum is attributable to the action of the air heater as an auxiliary or pre-condenser. Its effect on fuel consumption is due, in part, to the reduction of the duty of the pump supplying the condenser with cooling water.

Steam Raising with Low-Grade Fuels

LOW-GRADE fuels produced in the mining and preparation of bituminous coal may be divided, on the basis of composition and size, into 3 classes:

1. Coarse-grained material with ash content up to 50 per cent and moisture up to 20 per cent. This class includes coal from very impure seams, culm, and the middle products of washing and sorting processes.

2. Fine-grained material with ash content up to 40 per cent and moisture up to 30 per cent, which includes the fine dust from screening plants and the sludge residues of washing processes.

3. Small coke and coke breeze, produced in quenching and breaking coke, with ash content up to 30 per cent, moisture up to 20 per cent, and gas from 1 to 15 per cent.

These low-grade materials may be utilized in either of 2 ways: They may be burned under steam boilers, with or without admixture of other fuels, or they may be gasified in gas producers. Both methods have been under investigation for several months by a special commission representing mining interests in the Rhenish Westphalian district, Germany, and reports of individual tests have appeared from time to time in the pages of Gluckauf and other German periodicals. The steam-raising tests are now concluded, and a summary of the conclusions reached by the commission, as to the relative suitability of the various classes of low-grade fuels for boiler firing and their comparative efficiency under various methods of firing, has been published.

Up to a certain limit of ash and moisture content, coarse material of Class 1 can be fired under boilers with fair economy without admixture with other materials. The steam-raising efficiency is, however, very low, and fuels of this character can be employed advantageously only in very large installations. Very little advantage is to be gained by the application of forced draft, and the use of these fuels is therefore restricted to very special cases.

Fuels of Classes 2 and 3, when both are available, yield the best results when fired together. Coke breeze or fine non-caking coal mixed with the sludge of a caking fat or gas coal high in volatiles is an excellent boiler fuel. In this case forced draft increases the steam-raising efficiency, whether it is produced by steam jets or by fans.

Coke breeze alone, without admixture of fine coal, provided it contains at least 10 per cent of volatile matter, can be used with satisfactory results with the assistance of forced draft. When the volatile content is below 10 per cent, and no suitable fine coal is available for admixture, coke breeze must be formed into small briquettes with the aid of tar or sulphite pitch, or, still better, tar-pitch residues. These briquettes are easily made, hold together well in the furnace, and produce a very satisfactory boiler output. The cost of the briquetting process, however, forbids the utilization in this manner of coke breeze with ash and water content exceeding 25 to 30 per cent.

Coke breeze with a low percentage of volatile constituents and high ash and moisture content, and coal dust and sludge low in volatiles, are not adapted to boiler firing. For these materials, as for culm except

in very special cases, the only rational method of utilization is in the gas producer. It is not to be imagined, however, that for the other fuels mentioned gasification is a less economical method of utilization than boiler firing. The latter method has the advantages of simplicity and lower capital cost, and in cases where suitable materials are available, plant managers will be satisfied to use low-grade fuels for steam raising, with the assistance of forced draft, and possibly of briquetting. On the other hand, for the utilization of by far the greater quantity of the available low-grade materials, gasification is the only practical method.

LOCOMOTIVE TUBES AND THEIR TREATMENT*

By F. N. Speller

MUCH of the development of the tube industry is due to the railroads; in fact the invention of lap welding may be traced to the necessity which arose on the building of George Stephenson's first locomotive for a tube which would be safer and stronger than the butt welded tube, the only one made at that time. Since Stephenson's day the manufacture of locomotive tubes has increased in quantity and quality as the demands of railroad service became more exacting and the whole tube industry was no doubt favorably affected thereby.

Seamless steel tubes were introduced about 1886 and established a new standard of strength, ductility and endurance under many conditions of service. Later on a satisfactory grade of soft steel was produced which could be lap welded like charcoal iron, and this also has been much improved, so that we now have practically 3 classes of tubes for locomotive service—charcoal iron (lap welded), steel (lap welded), and seamless steel.

Charcoal iron formerly was made from a special grade of pig iron made in a small blast furnace using charcoal fuel. The product of this furnace was charged into the refinery, where about one-half of the impurities were oxidized and fluxed away, the metal being subsequently treated in lots of 300 lb. or so in a slightly modified type of the old catalan forge with charcoal as fuel. The use of so much charcoal has necessarily been stopped, and in many other respects the manufacture of charcoal iron for tubes has of late years been considerably modified.

When we speak of steel in this paper it refers more to the method of manufacture than the finished product, as the steel used in the manufacture of tubes, as a matter of fact, is a pure form of iron and, like the older steel, cannot be tempered.

A special grade of Bessemer steel was at first used in the manufacture of lap welded tubes, on account of its superior welding quality, but later on had to be abandoned as under some conditions it was found to develop brittleness in the beads after the tubes had been in service some time. The substitution of basic open hearth steel low in carbon and with less than 0.05 per cent phosphorous and sulphur has been found after more than 2 yr. trial to do away entirely with any tendency of this kind, and as now made there is little difficulty in securing a strong weld with this steel. Seamless and lap welded steel tubes are now made from practically the same grade of soft basic open hearth steel.

Let us take up what seem to be the main points requiring attention in the locomotive tube in order that it may give the best service under modern conditions.

FIG. 2. COOLING TABLES AT BOILER TUBE FURNACES IN THE M'KEESPORT MILL OF THE NATIONAL TUBE CO.

*From a paper read before the Pittsburgh Railway Club.

1st. Resistance to Corrosion—The manufacturer should furnish a tube in the best possible condition to withstand corrosion and pitting, that is, the metal should be as uniform in composition and density as it is possible to make it. Much can be done to lessen the tendency to pitting by proper attention to the making of steel and the way it is worked. We have been experimenting on this problem now for several years and have gone to considerable trouble in the matter of testing and inspection of material and in the process used for manipulating the steel, so as to produce a tube which will resist corrosion as well as iron can be made to do, and judging from the reports of comparative service tests which have been received, steel so made is, in this respect, at least the equal of the best charcoal iron.

After all, however, the solution of this problem is largely in the hands of the user. Iron or steel will corrode in spite of anything that can be done if certain elements are in solution in the water, particularly dissolved oxygen or carbonic acid. By the removal of these harmful agencies corrosion may be reduced to practically nothing. It is generally understood nowadays that water conditions have everything to do with corrosion, and the simplest solution of the problem is to treat the water with the object of making it as harmless as possible.

2nd. Leaking in the Flue Sheet—The construction and handling of the engine has so much to do with the trouble experienced from leaky flues that it is difficult to determine how much, if any, of the responsibility for this should be placed on the tube material. If railroad engineers will tell us what qualities are required in the tube to make it hold tight in the flue sheet, we will be glad to follow their suggestion as closely as possible. At the present time the steel tube is made as stiff as possible consistent with the best welding quality and ability to stand up successfully under expansion and beading in the tube sheet.

3rd. Strength and Ductility of Material—The tube should be of such quality as to stand repeated tightening in the flue sheet without cracking or showing undue evidence of fatigue, nor should these weaknesses develop during the life of the flue in service. The material found best adapted to give these properties is a special grade of soft open hearth steel carrying not over 0.05 per cent phosphorus or sulphur.

4th. Weldability—The quality of the metal and method of handling are equally important in safe ending. Soft steel has been found somewhat harder to weld than charcoal iron, but it has been greatly improved in this respect. The necessity for a good welding quality steel is of first consideration in making locomotive tubes so that they may be easily safe ended, and this point has received much study, especially in the manufacture of lap welded tubes where it is, of course, one of the first essentials to manufacture. Charcoal iron carries considerably more impurities than soft open hearth steel, and these impurities form a self-fluxing mixture which facilitates welding.

Railroad specifications have been so tightly drawn on composition in some cases as to work against the production of a good quality of steel for locomotive boiler tubes by calling for unnecessarily low phosphorus and sulphur. There is now very good reason to think that a mistake has been made in this direction and that the general welding quality of the steel would be much improved, and the steel at the same time would lose nothing in other respects, if the maximum phosphorus and sulphur limits were both raised to 0.05 per cent. With producer gas, now generally used of necessity, it is a very difficulty matter to keep the average sulphur in the heat below 0.035 per cent, and in order to remove this sulphur in the open hearth furnace the steel has to be held and worked in such a way as frequently to leave it dry and difficult to weld.

Before the steel can be welded in practice a fluid cinder must be formed on the surfaces which are to be united. If the metal is heated too far above the point at which this cinder should flow, it will be burned and destroyed. We endeavor to have the range of temperature between the cinder-forming and burning points in the steel as wide as possible so as to assist in lap welding and give the largest margin of safety in safe ending.

FIG. I. STANDARD TEST OF NATIONAL TUBE CO. ON LAP WELDED STEEL BOILER TUBES

5th. Uniformity of Material—This is a quality which the tubes should have in a high degree, both as to physical and chemical properties. There is no difficulty as to the average steel tube nowadays standing the Master Mechanics' tests made on one sample out of each hundred tubes. We have, however, recently designed a machine to make the flange, crushing down, and flattening test on each end of every tube in the manner shown in Fig. 1. This gives assurance, both as to the character of the metal in each individual tube and also, in the case of lap welded tubes, as to the welding quality being satisfactory. Steel tubes are now made in one grade of material suitable for either body tube or safe-ending.

In 1891 a great celebration was held in the city of Washington in honor of the first centennial of American patent history. There were 450,000 patents then in the files of the patent office. Noted speakers all wondered and marveled at the tremendous progress of invention during the hundred years they were viewing in retrospect. Since then 20 years have passed; yet in those years more patents have been applied for, and more have been issued than in all the hundred years that went before.

The bureau of navigation reports 108 sail and steam vessels of 10,938 gross tons were built in the United States and officially numbered during the month of October. Seventy-three per cent were steamers.

Questions and Answers

To help you when in trouble; give name and address. If quick answer is wanted, enclose a stamp for reply.

Adjustment of Connecting Rod

WILL you kindly advise me whether or not a connecting rod on a Corliss engine, made like the accompanying drawing, will shorten in keying up on the brasses. If it will where should the shims be placed to lengthen it to its original length?

A. In regard to your connecting rod, since the take-up on both ends is in the same direction there will be practically no change in the length by keying up, as the wear will be nearly the same on the boxes at the 2 ends. If the cap screws which control the wedges were both outside the boxes, so that the wedges forced the bearings from each end toward the middle of the rod, then taking up would shorten the rod and it would be necessary to put shims on the inside of the boxes to take up wear.

If, on the other hand, both cap screws were on the inside of the boxes, so that the wedges forced both

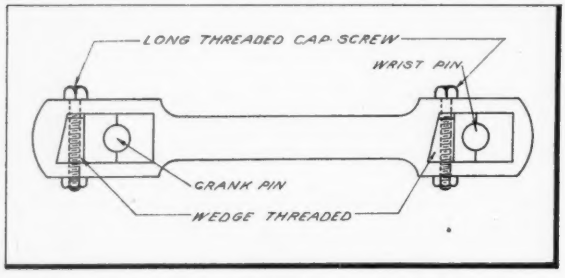


DIAGRAM SHOWING ADJUSTMENT OF CONNECTING ROD BRASSES

boxes toward the ends of the rod, the wear would tend to lengthen the rod and shims must be put in outside the boxes in order to shorten up.

Boiler Strength

WHAT is the formula for finding the strength of a double riveted lap joint? For example, what would be the safe pressure to carry on a boiler 40 in. in diameter, thickness of plate ¼ in., tensile strength 60,000 lb., ¾-in. rivets, pitch 2¼ in., double riveted, using a factor of safety of 5? J. H. B.

A. The strength is figured considering 2 methods of fracture. One would be for the plate to tear along the inner line of rivets, the other would be for all the rivets to shear.

It is necessary to consider only the section between the centers of 2 rivets in the same line, as the entire joint is made up of repetitions of this construction. Between these 2 points the strength of plate to resist tearing is: Thickness times (pitch of rivets minus diameter of rivet hole), times the tensile strength of the plate in pounds per square inch. This is usually taken at 50,000 for iron and 60,000 for steel, unless the actual values are known.

For the shearing of the rivets the strength will be: The area of cross section of 2 rivets, times the shearing strength in pounds per square inch of the rivet material. As these are ordinarily of iron, the strength is usually taken at 45,000 lb.

For your problem this figures out: Tearing strength of the plate is $\frac{1}{4} \times (2\frac{1}{4} - \frac{3}{4}) \times 60{,}000$, which figures out about 22,500 lb., and with factor of safety of 5 this would give a strength of 4500 lb. For the shearing strength we have the area of a ¾-in. rivet, which is $0.4418 \times 2 \times 45{,}000 = 39{,}700$, and with factor of safety of 5 would give 7940.

It is evident that the strength of this joint is governed by the tearing strength, and to get the efficiency we would find the strength of the plate between the centers of 2 rivets, which would be $\frac{1}{4} \times 2\frac{1}{4} \times \frac{60{,}000}{5}$ or 6750 lb. Dividing 4500 by 6750 gives 0.665, or the efficiency is 66½ per cent. Then, to get the safe pressure we have: 2 times the thickness, times the safe tensile stress, divided by the diameter and multiplied by the efficiency of the joint. In your case it would be: $2 \times \frac{1}{4} \times \frac{12{,}000}{40} \times 0.665 = 100$ lb. per square inch as the safe pressure.

Massachusetts Examination Questions Asked an Applicant for Second Class License

WHAT would you do if you had steam blow out of your boiler settings?

2. What would cause the more disastrous boiler explosion, a boiler with little or much water in it?

3. How much do you save by using a condenser?

4. How much does using a condenser increase the power of the engine?

5. What is lap for on a Corliss engine?

6. How could you tell that your piston needed centering without taking off the cylinder head?

7. How far are pump steam cylinders counterbored?

8. Would you calk a flange in your main steam pipe hot or cold?

9. What is a shaft governor on a riding cutoff engine for?

10. How does oil affect boilers if it gets into them?

11. If while shutting down a compound engine the condenser should stop what would you do?

12. If you had a condensing engine loaded all she could carry and your condenser broke down what could you do to keep running?

13. If the bursting pressure of boiler is 750 lb. why do they not run the pressure nearly to that in a hydraulic test?

14. In a small vertical boiler 36 in. or less diameter how would you stay it if you did not use stay bolts?

15. What is a twin air pump?

16. If the nipples on the back end of a Babcock and Wilcox boiler leaked what would you do?

17. If they leaked again in a week or so, what would be the matter and the remedy?

Ans. It is presumed that by the term boiler setting is meant the foundation of the boiler, or the brickwork enclosing it; if steam, or vapor appears to be finding its way out through the openings in the brickwork, it is an indication that there is a leak in either the steam or water space, or perhaps in the blowoff pipe inside the boiler walls. Under such conditions the speed of the feed pump should be increased to its full capacity; also the fire should be pulled, and the boiler allowed to cool as soon as possible, and repairs made.

2. The violence of a boiler explosion is directly in proportion to the amount of water in the boiler ready to flash into steam the moment a rupture is made large enough to release the pressure suddenly. Therefore, the larger quantity of water in an exploding boiler will cause the more disastrous explosion.

3. The saving effected by the use of a condenser depends upon the number of inches of vacuum maintained in the condenser. For instance, if the average steam pressure acting upon the piston throughout the stroke is 40 lb. per sq. in., and there is a vacuum of 26 in. in the condenser, there will be 13 lb. per sq. in. of resistance removed from in front of the piston, thus making available 40+13=53 lb. of pressure per square inches a saving of about 3 per cent.

4. See answer to question 3. Thus if an engine with an average pressure of 40 lb. per sq. in. and running without a condenser will develop 200 hp. The same engine will, by the addition of a condenser in which a vacuum of 26 in. is maintained, develop 265 hp.

5. The valves on a Corliss engine have only outside lap, the function of which is to cover the ports until the moment of admission or release occurs for each valve in its regular order.

6. Place the engine near the end of the outer or forward stroke; remove the gland from the piston rod stuffing box, and with a pair of inside calipers ascertain whether the rod occupies the center of the box, and also whether it is equidistant from the top and bottom guides, see sketch, if not, the piston needs centering.

7. Clearance in these cylinders is reduced to the smallest possible amount, therefore they are counterbored only far enough to permit the outside edge of the packing ring to project slightly over the counterbore.

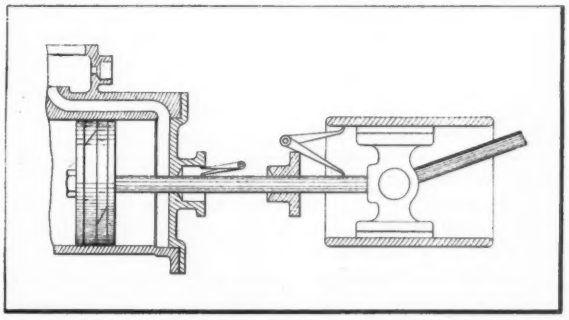
8. When it becomes necessary to calk a flange joint, or any other leak in the steam main, the work should be done if possible when the pipe is cold.

9. The function of the shaft governor and riding cutoff is to control the admission of steam to the cylinder in such a manner that the speed of the engine will be regular. This is accomplished by variation of the point of cutoff to suit the load on the engine.

10. If oil is allowed to accumulate in a boiler, it will in time form a coating on the inside of the sheets which will prevent the water from coming directly in contact with them, the result being a burnt, or blistered sheet. Oil in boilers is also liable to cause foaming.

11. In a case of this kind, what is done must be done quickly. Assuming that the condenser is of the jet type in which the condensing water mingles with the steam, and there is direct communication between the low-pressure cylinder and the condenser, the danger would be of the water being drawn into the cylinder by the suction of the piston during the strokes it will make after the throttle is closed, instead of this same water being drawn off by the air pump which it is presumed has stopped.

In all condensing apparatus there is, or should be, a "bleeder" valve for the purpose of admitting air directly to the condenser, thus destroying the vacuum at once, and stopping the inflow of water through the suction pipe. This "bleeder" valve should always be opened immediately after the throttle is closed. To meet an emergency such as is implied in question 11, the correct arrangement would be to have the engine equipped in such a manner that the exhaust from the



METHOD OF DETERMINING WHETHER OR NOT PISTON ROD IS CENTERED

low-pressure cylinder may be thrown open to the atmosphere, thus making a noncondensing engine of it.

12. If the engine is equipped as described in the latter portion of the answer to question 11, viz.: so that it may be run non-condensing, all that is necessary is to open communication between the exhaust and the atmosphere, discarding, for the time being, the condenser. The engine, however, will not develop as much power as before.

13. The object of the hydraulic test as applied to a boiler is two-fold; first, to ascertain whether there are any leaks in the boiler; and second, to ascertain whether or not the boiler is safe at the ordinary working pressure. If, while making a hydraulic test, the pressure was run up to near the bursting pressure, the boiler would be subjected to unnecessarily severe strains.

14. The firebox in a small vertical boiler is cylindrical in shape, consequently the sides do not require stays or braces. The top or flue sheet is flat, as is also the top head of the boiler, but these flat surfaces are sufficiently braced by the flues which connect them.

15. The expression "Twin Air Pump" implies that there are 2 air pumps exactly alike in every detail, but connected in such a manner that each may be operated independently of the other, or if required they may be operated jointly.

16. The boiler should be immediately shut down, and proper repairs made.

17. The trouble would be that the aforesaid connections were so badly corroded as to be beyond repair, and the remedy would be, the insertion of new parts.

Answers to Practical License Questions

IN looking over a recent issue of Practical Engineer I say an article by John L. Nash entitled "Injustice of Examination for License" with questions he

considers good and practical. As I am of the same opinion myself and thinking some of the readers of Practical Engineer would like to see them answered by a practical engineer I will try to answer them as I would if I were before the examining board.

1. What is understood by the term 100 lb. gage?

A. A pressure of 100 lb. pressure per sq. in. above the pressure of the atmosphere.

2. What is a square inch?

A. A rectangular area or portion of a surface the product of whose length by width in inches equals 1.

3. What pressure in pounds tends to render asunder from end to end a boiler 18 ft. by 72 in. at 100 lb. gage?

A. $P = p \times d \times l$.

Where P = Total pressure tending to render asunder
p = boiler pressure, or 100 lb.
d = diameter of boiler, or 72 in.
l = length of boiler in inches or $18 \times 12 = 216$ in.

$P = 100 \times 72 \times 216 = 1{,}555{,}200$ lb.

4. Name accessories necessary on a steam boiler for its safe operation.

A. Safety valve, water column, gage glass, gage cocks, pressure gage, fusible plug, feed line and blow-off line.

5. For what purposes are water columns, gage glasses, and gage cocks used?

A. To show the level of the water in the boiler.

6. What care should be given to keep them in safe working condition?

A. Clean and blow out 3 or 4 times on each watch.

7. Why is it necessary to have a pressure gage attached to a steam boiler?

A. To know pressure inside the boiler, and check the operation of the safety valve.

8. What care should it be given?

A. Occasionally it should be blown out when great care should be used not to turn the steam on too quickly, as sudden changes of heat damage the spring tube. It should be tested once in a while to determine its accuracy and especially at any time the safety valve pops at an apparently different pressure than that for which it is set.

9. How should it be attached?

A. To the highest part of the boiler, with a loop or goose neck, or a coil, between the boiler and gage to form a pocket for condensed steam, so that only cool water enters the gage with the steam pressure behind the water. It should never be set higher than the outlet from the boiler unless a coil or goose neck is used.

10. Name the fittings between gage and boiler.

A. Only a valve to shut the gage off for testing or repairs.

11. Should there be more than one gage on a boiler?

A. It is not necessary so long as you know the gage is correct; besides most plants carry a steam gage connected to the steam line in the engine room.

12. For what is a safety valve intended?

A. To relieve the pressure at predetermined point and avoid accidents by overpressure.

13. On what principle does it depend for operation?

A. The overcoming of one pressure by another.

14. What care should it be given?

A. Tested at least once a day by allowing the pressure on the boiler to rise just enough to open the valve; also keep the valve clean and free from obstructions.

15. Should there be more than one safety valve on a boiler?

A. It is not necessary to have more than one safety valve provided it is large enough, although in some cases two are put on and both connected to the same outlet from the boiler.

16. Should there be a valve between the boiler and the valve?

A. No, never. Should the valve be closed by accident or otherwise the safety valve would be useless.

17. What methods are used to get water into a boiler under pressure?

A. By means of a boiler feed pump or an injector.

18. How is the injector put in operation?

A. By opening the valve on the water line first, then opening the valve on the steam line. If the water supply is too great, water will appear at the overflow, in which case the feed water valve will have to be closed a little or more steam put on according to circumstances. Different makes have different operations, but the principle is practically the same in all. In some cases the injector has to lift the water in others the water is taken directly from the service lines. An injector will lift water from 6 to 26 ft. according to the temperature of the water and the steam pressure.

19. How is the boiler-feed pump put into operation?

A. First see that there is a valve open on the feed line to the boiler, that the suction and discharge valves are open, and that the exhaust valve and drips on the steam end are open. Turn steam on slowly; when the cylinders are warm turn a little more steam on until the pump moves slowly, open the air valve on the water cylinder until the water flows freely from it, then close it, and gradually bring pump up to the speed desired to keep a constant feed. Close the steam drips. Pump assumed to be in working order.

20. How stopped?

A. Assuming the pump to be used again, shut off the steam and open the drips on steam end.

21. Should the feed pump be run at a high speed to fill the boiler and then be stopped?

A. No. The pump should be run at such a speed as would insure a uniform feed or just fast enough to keep the water at a certain level in the boiler.

22. What valves, if any, should be between the feed pump and the boiler?

A. There is nearly always a discharge valve on the pump, but furthermore, there should be a check valve and a globe or gate valve.

23. Where should these valves be placed?

A. Set the globe or gate valve nearest to the boiler, with the check valve connected next to the valve by a short nipple. By closing the globe or gate valve, the check valve may be opened for inspection or removed for repairs.

24. When starting the feed pump, is there any special precaution to be taken?

A. Yes. See question 19.

25. What is the object of the blowoff pipe?

A. It is used in getting rid of mud or sediment which settles to the bottom of a boiler; also to empty the boiler.

26. Is there any special care to be given to the blowoff pipe?

A. Yes. The blowoff pipe in a majority of cases leads into a sewer and, being under ground is not noticed as it would be under other conditions. Therefore the valve on the blowoff line should receive regular attention to see that it does not leak, for a leaky valve on a blowoff line is in some cases dangerous and in any case a source of waste. Where the line is subject to heat it should be protected by a sleeve or covering of some heat resisting material. The connections between the boiler and the blowoff valve should be examined carefully as an accident in that part of the line would mean that the boiler would have to be shut down at once.

27. How often should the blowoff valve be opened?

A. This depends on the condition of the water, the quantity used and the number of hours per day the boiler is in operation. If the water is very dirty the valve should be opened at least once for every 8 hr. run and the water let down in the boiler, say, about 3 in. each time. If the fire were banked part of the time open the blowoff valve just before starting the boiler again, because the boiler having been idle the sediment in the water would settle to the bottom, which, as soon as the boiler was again started, would be disturbed by the circulation.

28. What bearing has scale or oil in a boiler on the safety of its operation?

A. Scale, say 1/32 in. or less, in thickness, is thought by many to be an advantage, since it protects the plates from the corrosive action of acids in the water. If, however, the scale becomes ¼ in. thick or more, heat is transmitted through the plates with difficulty, more fuel is required, and there is danger of overheating the plates. Incrustation in many cases has led to disaster by stopping up the feed line, the blowoff line, or the connections to the gage glass. Again, the coat of scale may hide a dangerously corroded piece of plate or a defective rivet head which otherwise would be discovered. When oil settles and mixes with the scale it makes a spongy crust, which remains in contact with the plates, being too heavy to be carried away by the circulation of the water. Many cases of overheated and burned plates are the result of allowing oil to enter the boiler; also, many boiler explosions are reported as having been caused by a coating of oil on top of the water in a boiler.

29. What precaution should be taken in installing steam pipes?

A. Steam pipes should be so arranged that no pockets or sharp angles are formed in which water may collect, but if these can not be avoided they should be provided with a drain cock or steam trap. If the water of condensation is not removed it is liable to cause serious damage when steam is turned on, the presence of water in a steam pipe being the cause of the so called water hammer which is often heard in steam heating plants. It has experimentally been shown that the pressure produced by the water hammer may be 10 times that which the pipe was expected to sustain. In some cases the water hammer has caused boiler explosions by bursting the main steam pipes. Proper provision also should be allowed for expansion of steam lines.

30. Would the complete rupture of a large pipe be more disastrous than that of a small one?

A. Yes, the complete rupture of large steam pipes relieves the boiler pressure, permitting the generation of a vast amount of steam almost instantaneously, a frequent cause of explosions.

31. In what proportion?

A. In portion to the cross sectional areas of the pipes which vary as the square of the diameter. A 2-in. pipe has 4 times area of a 1-in., a 4-in. pipe has 4 times area of a 2-in.

32. For what is the governor on an engine?

A. To control the speed.

33. On what principle does the throttle governor depend for its action?

A. It depends for its action on centrifugal force. If the speed of the engine increases, the balls fly out, which by a suitable mechanism partly closes the valve; when the speed decreases the balls come in and open the valve again.

34. On what principle does the flywheel governor depend?

A. Shifting the eccentric so as to change its throw and angle of advance, operated by centrifugal force in the governor. As the speed increases the weights move out and as the speed decreases the weights move back to their original position with the assistance of springs. As the weights move outwards the travel of the eccentric is shortened and the engine takes less steam, as the weights come back to their original position the travel of the eccentric is lengthened and the engine takes more steam.

35. Do you know of any scheme or device in use to prevent an engine from exceeding the speed it is intended to run at in case the governor should fail?

A. Yes. A mechanical device known as an engine stop, or over-speed device.

36. Is it necessary to use a safety stop with every type of governor?

A. I think it ought to be compulsory. With connections in different parts of a building, many lives would perhaps be save by the automatic stopping of an engine when accidents occur.

37. If the governor belt should break, how should the stop operate?

A. If the governor did not shut off the steam the engine would increase in speed until the safety stop or speed limiting device would close the steam off. The operation would depend on the make of stop and how wired. One make would close an independent valve in the main safety stop valve and another make would close the main valves; the former working by a trip hook and weighted lever arm, and the latter by a trip hook, rope and counter weight connected by a sprocket chain or geared to the main valve. The trips are released on both makes by an independent governor supplied with each make of safety stop and driven from the engine about 3 times as fast as the engine governor to make it more sensitive. This governor makes or breaks contact with a magnet which in turn releases the trip hook depending on how wired.

38. If the speed is exceeded and the belt does not break, how is the safety stop intended to operate?

A. The operation would be same as in question 37.

39. If a spring should break on a shaft governor, what way would it affect the speed of the engine?

A. If a spring broke the centrifugal force would carry the weight outwards until it came in contact with the stop or limit of travel; in so doing the travel of the eccentric would be shortened, the engine would receive less steam, and slow down.

40. What would be the probable result if the main belt broke, or the circuit breaker came out and the governor failed to operate at the same time with no safety stop?

A. The probable result would be a wrecked engine, if not attended with loss of life and a damaged engine room.

41. Why?

A. Because in all engines the movable parts are made to stand a certain strain, allowing a certain factor of safety but not enough for such accidents as the failing of a governor. Take for instance an engine designed to run at 80 r.p.m. with a flywheel whose dimensions are, outside dia. 10 ft. width of face, 20 in. and thickness of rim 6 in., made of cast iron weighing 0.261 lb. per cu. in. To find the centrifugal force which the flywheel will stand with safety use the following formula $F=0.00034\ W\ R\ N^2$

Where F=centrifugal force in pounds
W=Weight of revolving body in pounds
R=Radius in feet of circle described by the center of gravity of revolving body
N=Revolutions per minute of revolving body.

In calculating the centrifugal force of flywheels it is the usual practice to consider the rim of the wheel only, and not take the arms and hub into account. In this case R would be taken as the distance between the center of the rim and the center of the shaft. First calculate the weight of the rim. The diameter of the rim=$10\times12=120$ in.; the diameter of the circle midway between the inside and outside diameters of the rim=$120-6=114$ in. The number of cubic inches in the rim=$114\times3.1416\times20\times6=42{,}977$ cu. in., and $42{,}977\times0.261=11{,}217$ lb., or weight of flywheel rim.

Radius=$114\div2\div12=4.75$ ft.

$80^2=6400$

Then $0.00034\times11{,}217\times4.75\times6400=115{,}939$ lb. Now if the speed of the engine were to increase to 90 r.p.m., the centrifugal force would be changed from 115,939 lb. to $0.00034\div11{,}217\times4.75\times8100=146{,}735$ lb. and as the speed increased the centrifugal force would increase in proportion until flywheel were wrecked.

42. If a direct heating system, designed for 5 lb. back pressure on the engine failed to heat sufficiently on a very cold day, what would you do?

A. Turn on some live steam through a reducing valve which should be set so as not to cause more than 5 lb. back pressure on the heating line. If there were no live steam connection increase the back pressure a little by moving the weight on the back-pressure valve provided the load on the engine would allow for the change in back pressure. If not, make a live-steam connection to the heating line and admit a little live steam at boiler pressure.

John Mitchell.

A REMARKABLE DECISION relating to trade secrets was recently handed down by the highest German court. Several men who had been employed in a factory started a competing works and utilized, in the new undertaking, their knowledge of various decorative designs of the former employer. The latter brought suit on the basis of the German law against unfair competition and the lower courts decided in his favor, but the highest court reversed this decision and stated that the members of the new company acted within their lawful rights. According to the opinion of the court, trade secrets which are confided to an employe, or which become known to him in a legitimate manner in the course of his employment, may not be disclosed by him to outside parties while he remains in that employ; but the prohibition ends with the period of employ, and the acquired knowledge may be used thereafter in any way.—Machinery.

READERS' SERVICE DEPARTMENT

HE wanted to know how to brick up his boiler. The following letter illustrates the kind of service this department is ready to give at any time.

Dear Sirs:

I am in need of some information in regard to bricking up a boiler to get the best result. Could you give me a cut of how to do the work and how it should be done? The boiler is a 100 hp. return tubular boiler. We have three installed in our plant and use all three to do the work of two and we burn twice as much coal as we ought to to keep up steam. I do not think the combustion is right. Please give me the information and the right measurements if you can.

The Answer from the Readers' Service Department.

Dear Sir:

In regard to the bricking up of your boiler, the proper proportions for the furnace box and combustion chamber depend on the kind of fuel that you are using. If you will write to ———— and ask for their book on horizontal tubular boiler setting, you will get a great deal of valuable information in a small space and clearly given.

There is only one point on which you need to be cautious. You will find that they give the distance from the grate to the under side of a 100 hp. boiler as 28 to 30 inches and the distance from bridge wall to boiler as 12 inches. These figures are for anthracite coals. If you are burning a western bituminous the figures should be greatly increased. The distance from grate to shell should be nearer 40 inches and the distance above the bridge wall 20 to 24 inches, and it is well, if you can get the room, to throw an arch above the fire doors and beneath the boiler shell extending out 12 to 18 inches over the grates.

The point is to arrange the setting with a bituminous coal so that there will be plenty of time for complete combustion of the gases before they come in contact with the boiler surface and begin to cool off.

Aside from these precautions you will find the instructions in that book reliable and I believe it will tell you all that you will need to know in regard to the latest practice. Very truly,

This department is ready at all times to give you opinions from the editorial staff, and if necessary, get expert advice from a specialist in any line and give you the information he furnishes free of charge. A letter addressed to the Readers' Service Department will be answered promptly.

REPAIRS TO A STEEL CHIMNEY 100 ft. high and 6 ft. in diameter were recently needed in 7 of the courses in the middle of its height. The top 5 courses were in good condition and sooner than lower them to the ground and then raise them again, involving the handling of almost 2 tons, the Chicago Bridge & Iron Works, which had the contract for the work, supported them on a scaffold while the lower sections were replaced. This scaffold had 4 6 by 6-in. posts X-braced with 1 by 6-in. plank and it was in service about a fortnight.

THE BUILDING FULL of contented men during cold weather is the one properly equipped with heating apparatus kept in good order and working by an efficient engineer.

Problems for Discussion

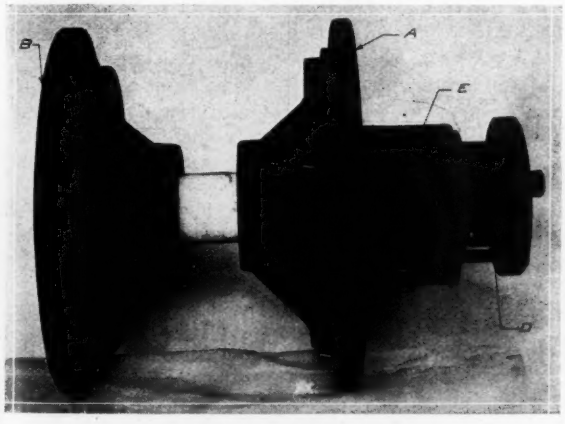
What Would You Do Under These Conditions?

PECULIAR ACTION OF AMMONIA COMPRESSOR PACKING

WE HAVE been having trouble with the stuffing box on an ammonia compressor as follows: The compressor has a head on each end; the head marked B is solid and has no outlet, but forms the bearing for the end of the crank shaft. The head marked A has a stuffing box and gland for the end of the crank shaft to extend through to take the driving pulley. This stuffing box has been packed with Ammonia Ring Packing; a single ring is placed in the bottom of the box; next they use double rings and then the top ring is a single ring. The gland D is then put in place and the nuts on the studs are tightened up to prevent the ammonia from leaking, while the compressor is warm.

After the compressor has made the day's run, and shut down for the night and cools off, the ammonia leaks some, and the engineer tightens up the gland to prevent this leakage, while it is cold; when the compressor is started up the next day and warms up, the stuffing box bursts or the heads break off the studs.

The manufacturer experimenting with the cause of this trouble took one of the heads marked A separately,



THE COMPRESSOR HEADS AND STUFFING BOX

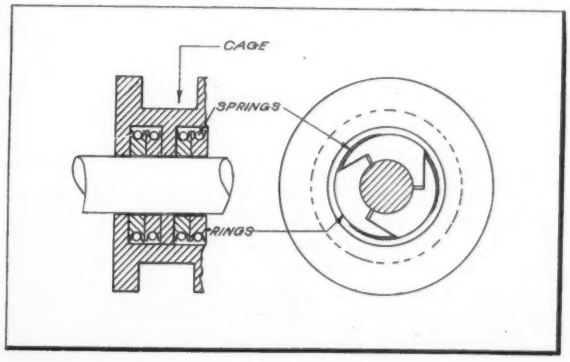
and entirely away from the compressor, ran a piece of pipe through where the shaft regularly goes, connected the pipe that replaced the shaft to a steam line with an air cock on one end to drain condensation, tightened up the packing gland, while it was warm to the same tension that it would have on the compressor; then let it cool off, tightened up the packing gland, and turned on the steam.

In the first test, stuffing box was broken, and in the next the heads pulled off the studs.

Can someone advise me of a remedy for the above trouble. Packing manufacturers do not seem to know how to remedy it, yet it is only recently that we have had this trouble, and we are using the same packing that was formerly used when the glands were very much lighter, and we did not have the trouble. S. C. H.

As to the ammonia compressor problem, every fibrous packing (i. e., nonmetallic) expands with heat and contracts with cold. If the engineer could slack off on the gland, as it warmed up, all would be O. K. He might put on nuts with teeth and by means of gearing arrange to adjust gland nuts while running. Large machines are so built.

If he uses a diagonal packing, he will decrease the trouble and perhaps eliminate it, although with any packing the gland should be adjusted as the temperature varies. The diagonal will give less trouble than the



ARRANGEMENT OF THE METALLIC PACKING ACCORDING TO WALKER PATENT

other kinds if the glands are not screwed too tight and the packing is allowed to adjust itself by the internal pressure.

Of metallic packings—one of the Walker type should work well and may be used if there is clearance enough to admit of its being applied. The Walker type is that composed of inverted snap rings held on by garter springs and working in a cage. Originally made under "Walker" patents now expired, and now made by France Packing Co., and others.

Why the packing does not work now must be because of the quality of the goods if the same style worked all right before. The resultant binding is to be expected, however. The extreme change of temperature must be compensated for by adjustment of the gland on any fibrous packing to a greater or less degree.

W. E. Sanders.

I believe that we have arrived at a solution of the trouble. We find that the packing rings now used are 1/16 in. smaller in diameter than the stuffing box, so that it is necessary to squeeze the rings enough to fill up this 1/16 in. space and make the rings bear on both box and shaft. This made the glands so tight that there was no chance for expansion, hence an enormous pressure was created as the packing became heated, and this broke the box. S. C. H.

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UNIFORM BOILER SPECIFICATIONS

It is evident that, in order to secure safe construction and operation of high-pressure boilers, some specifications and standards must be adopted, so long as humanity remains as it is. Boiler manufacturers and most engineers have stood always for the best, but penurious buyers and some indifferent operators make careful control by state or municipal authorities necessary.

Requirements of safety are, however, reasonably easy to establish, and there is not sufficient difference of opinion as to the conditions to meet these requirements so that diversity of standards is required. A good, uniform standard and specifications in all states will have many advantages. Manufacturers can establish a uniform practice to meet them, which will reduce cost of production and, therefore, cost to buyers; buyers and owners can easily make sure of getting a safe installation by demanding that it meet the uniform standards and specifications; engineers can easily become familiar with the uniform standard, which will apply in all parts of the country, and make sure that their plants conform to that standard.

There is no good apparent reason for diversity and there are numerous reasons, besides those given for uniformity. The effort being made by the Boiler Manufacturers Association to secure adoption of standard specifications is worthy of support by all interested in the advancement of power plant practice.

BOGUS SUBSCRIPTION AGENTS

Most men are honest, otherwise business could not be done at all. If it were necessary to demand a certificate of honesty from everybody whom one meets, life would not be worth while.

This statement applies to men who are carrying the enthusiasm for progress throughout the land by bringing to the attention of those who ought to be reading them, the merits of the journals which stand for progress in all lines of endeavor. Most of them are honest and to be trusted; and those who are will never object to proving their honesty, and right to take subscriptions.

But there is a small number in every line of work who take advantage of human credulity and the desire to get more than a fair return for money paid, to make all sorts of impossible offers, gather in money without authority and depart for parts unknown. It is difficult to catch these fakirs, for the victim of the fraud does not enter a complaint for several weeks and by that time the bogus agent is hundreds of miles away, with his trail unknown.

The fraud can be detected by two signs; the authorized agent always has a letter of authority or receipt forms bearing the name of the paper that he represents and the publisher; his offers are reasonable in value and conform to the printed offers of the publisher in advertisements and circulars, and the agent usually has these offers in printed form with him. The bogus agent, on the other hand, can show no authority, usually gives a receipt, if at all, on a leaf of a book that can be bought at any stationary

store; and makes offers and promises which are entirely impossible for the money asked.

Practical Engineer stands squarely behind all its offers and promises. They are of exceptionally good value, but they are all reasonable, and are fully set forth in printed matter. In case of doubt, demand evidence of authority, and caution all your friends to do likewise. And if offers which seem impossible are made, write to this address with full particulars. You will lose nothing by it; you may save cash and disappointment and render a service to brother engineers by preventing further fraud on the part of a bogus agent.

LOSS IN STORING COAL

As a result of tests made by the Bureau of Mines on the effect of weathering coal and of storing it submerged, which have extended over some 3 years, and which were conducted on New River, Pocahontas and Pittsburgh coals and black lignites from Sheridan, Wyo., it has been determined that weathering for 1 year in the open caused less than 1 per cent loss of calorific value in the New River coal, and there was practically no loss in the submerged samples whether fresh water or salt water was used.

Pocahontas coal weathered in the Isthmus of Panama for a year in a 120-ton pile lost less than 0.4 of 1 per cent in heating value and suffered little in physical deterioration. Pittsburgh coal after 6 months outdoor exposure showed no loss in heating value, even in the upper surface layer of the bins, but the Wyoming coal lost from 5.3 per cent in one case during 2¾ years' exposure up to 3.5 per cent in another case during the first 3 months. There was bad slacking and crumbling of the lumps on the surface of the pile, but this slacking did not penetrate more than 12 to 18 in. even during the longer period of exposure.

Outdoor weathering tests made by Professor Parr of the University of Illinois, and Mr. Bement of Chicago on Illinois coal has shown that from 1 to 3 per cent of the calorific value is lost in a year by weathering.

Storage under water preserves the heating value and physical strength of coal, but necessitates firing wet coal. This means evaporating in the furnace from 1 to 15 per cent of moisture, according to the kind of coal, but if firemen are permitted, as is frequently the case, to wet down the coal before firing, so as to make a "hotter fire," the moisture taken on during storage is of little consequence.

Submerged storage is an absolute preventive of spontaneous combustion, and on that account may be justified with some coals, but the saving from avoidance of weathering does not seem to warrant submerged storage. Investigating the question of spontaneous combustion during storage, it is found that if oxidation occurs at a rate which raises the temperaaure above a certain point about 212 deg. F., the increase in heat developed overbalances radiation and the temperature will rise to the ignition point if the air supply is adequate. The likelihood of spontaneous combustion depends, therefore, on the surface exposed for oxidation, the surface exposed for radiating heat, and the air supply.

High volatile matter was not found of itself to increase the liability to spontaneous heating, but the mixture of unequal sizes, such as dust and large lump, as found in run of mine, if it be arranged so that the lumps cause air passages into the interior of the pile, tends to produce heating and thus increase escape of volatiles and loss in its heating value. It was not possible to determine that moisture in coal or sulphur of themselves add to the spontaneous combustion effect, but coal in which moisture is present in large quantities, and also certain coals which contain a considerable amount of sulphur seem to have other constituents which increase the liability to spontaneous heating.

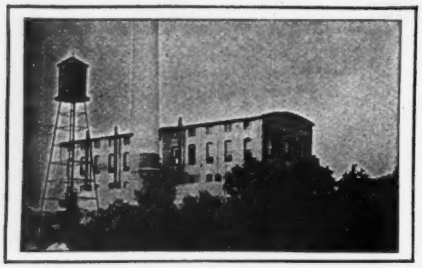
Freshly mined coal or fresh surfaces exposed by crushing have great affinity for oxygen, but after a time become coated or seasoned, so that, if coal is rehandled and cooled after 2 months' storage, there is little likelihood of after heating. Recommendations to avoid spontaneous combustion are as follows:

1. Do not pile over 12 ft. deep, nor so that any point in the interior will be over 10 ft. from an air cooled surface.
2. If possible store only lumps.
3. Keep out dust as much as possible, thereby reducing handling to a minimum.
4. Pile with lump and fine distributed evenly and do not allow lumps to roll down from the peak and form air passages at the bottom.
5. Rehandle and screen after 2 months.
6. Keep away external sources of heat even though moderate in degree, so that the temperature will not rise above 212 deg. F.
7. Allow 6 weeks for seasoning after mining and before putting into storage.
8. Avoid alternate wetting and drying.
9. Avoid admission of air to the interior of the pile either by openings around objects such as timbers or irregular brick work or through porous bottoms such as coarse cinders.
10. Do not ventilate by pipes, as they often do more harm than good.

REDUCING FIRE LOSSES

MANY tests have shown that it is perfectly practicable to build a structure which, while not absolutely fireproof, cannot well be ruined, and is seldom more than superficially damaged, even by the fiercest fire. More important than this, however, is the fact that existing buildings, not in themselves fireproof, can be made almost perfectly free from serious danger of fire by the simple expedient of fitting them with a system of automatic fire fighting devices, the most important of which is the automatic sprinkler. Fire doors would, for a limited time, hold a fire to a somewhat restricted area; but automatic sprinklers, while doing this in even better degree, would also perform the positive service of either extinguishing the fire completely (which they do in about ⅔ of all cases) or of preventing it from spreading until the fire department, which has been summoned by the automatic alarm, set off by the sprinklers themselves, can arrive upon the scene and end the trouble.

The direct bearing of all this upon insurance premiums rests largely with the underwriters. It has been found possible in the average case to reduce the fire insurance premiums on property so protected, to such an extent that the entire equipment may be paid for by this reduction within 3 to 5 years. After this period the reduction is a clear gain, and during the entire life of the building after the sprinklers are installed the owner is saved from apprehension of a disastrous fire.



Power Apparatus

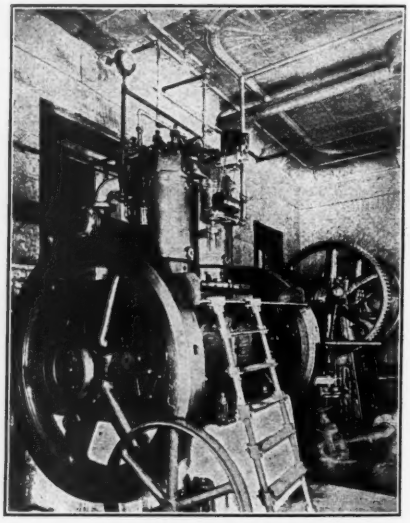
In Shop and Market

New Ideas in Making, Buying and Selling

PUMPING COSTS

A municipal water works that reduced pumping costs by a gas engine power pump equipment

HIGH economy of the gas engine driven power pump is generally known, and interesting data of results obtained with this type of pumping equipment are frequently received. Among these, the results obtained in the plant of the Bellevue Water Works, Bellevue, Ohio, is of particular interest —a saving of 75 per cent having been shown in this plant by the installation of this type of equipment.



GAS ENGINE DRIVE TRIPLEX PUMP IN BELLEVUE WATER WORKS

This includes the cost of fuel only; if the other items, such as maintenance, attendance, etc., were taken into consideration, even greater increase in economy would probably be evident.

In this city an average of between 600,000 and 800,000 gal. of water, against a normal pressure of about 42 lb. and a fire pressure of 110 lb. are used in 24 hr. The stand pipe is cut out in case of fire and the pressure is taken direct from the pump.

The original equipment which had been in service several years, consisted of a reciprocating steam pump. About a year ago this equipment was replaced by a double-acting triplex power pump, made by the Goulds Manufacturing Co., Seneca Falls, N. Y., and a natural gas engine, made by the Bruce-Macbeth Engine Co., Cleveland, Ohio. The pump has 9 in. by 12 in. cylinders and the engine is rated at 55 hp.

Bellevue is located in the natural gas belt and gas for fuel under the boiler for the old steam pump equipment cost 15c a thousand feet. Gas for the engine now used costs them 30c a thousand feet.

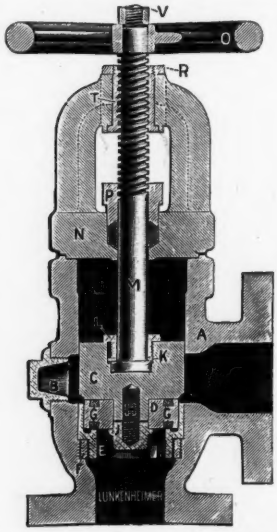
During the month of August, 1910, with the steam pump, 20,000,000 gal. was pumped at a fuel cost for gas under the boilers of $128. During the month of August, 1911, with the new power pumping equipment, 21,000,000 gal. was pumped at a fuel cost for gas supplied to the engine of $31.

During a test of 9 days, the gas engine and power pump delivered 5,900,450 gal. of water with a gas consumption of 31,000 ft., which is equivalent to about 5 cu. ft. of gas per 1,000 gal., giving a cost of 3/20 of one cent per thousand gallons.

AN IMPROVED BLOWOFF VALVE

HEREWITH is illustrated an improved design of blowoff valve which embodies a number of important features. In this valve the plug fits snugly in a saparate and easily removable bronze casing, which can be readily replaced when worn. Any accumulation of scale or sediment that might remain on the seat before the disc is brought in contact with it, is washed away by the water which passes around the plug when seating.

It will be seen that the plug C carries a reversible, double-faced disc D, secured to the plug by stud H



IMPROVED DURO BLOWOFF VALVE

and nut J; this plug C is guided perfectly in the valve body A. The bronze seat ring E is screwed into a second brass ring F, the object being to make it possible to renew E very easily in case it becomes worn.

At the back of the valve is a plug B, the use of which is to permit the introduction of a rod to clean out the blowoff pipe when desirable. A hose may also be inserted to wash off the seating surfaces, particularly after the boiler has been cleaned. The stem M,

which raises and lowers the disc C, is held in place by locknut L, which is prevented from unscrewing by nonrotating washer K. The threads of the stem N operate within the bronze bushing in the top of the yoke, which bushing can easily be removed.

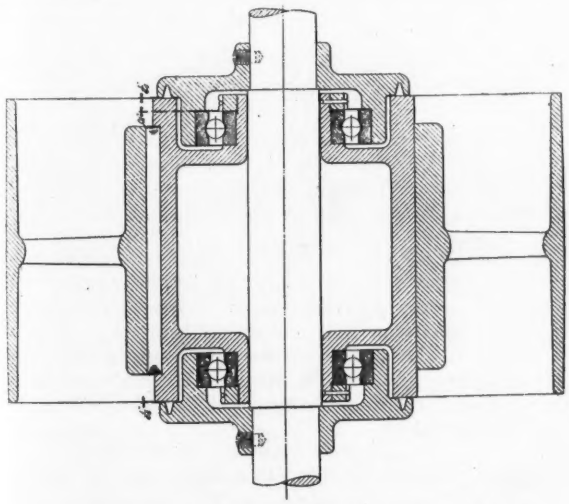
It will be seen from this description that all parts of the valve have been designed that they can be easily renewed when worn or broken. The disc D, having 2 lead alloy bearings G G, it can be replaced at small cost, or the user of the valve can melt out the old babbitt and pour in new metal, and after this is faced off, the disc is as good as new. The manufacturers claim that the lead alloy, as usually furnished in the discs, has given satisfaction, but to meet unusual conditions, a harder or softer alloy can be had.

In operating the Duro valve, when it is desirable to close it, the disc is screwed down in the usual manner. As the edge of disc D approaches the cylindrical extension of F, these edges shear and cut off any scale or sediment which might pass. As the disc D continues to approach the seat bearing E, the leakage of water between them will effectually wash off any scale or sediment which might have accumulated thereon. The result of this is that when the disc is perfectly seated no scale or sediment can remain between the bearings.

This article, known by the trade name of Duro, is constructed by the Lunkenheimer Co., Cincinnati, Ohio.

BALL BEARING FOR VERTICAL LOOSE PULLEY

THE drawing shows a mounting recommended by the Hess-Bright Mfg. Co. for the application of Hess-Bright ball bearings to a vertical mule pulley. It is applicable, however, in other cases where a loose pulley is mounted on a vertical shaft. Two objects are attained by the peculiar form of mounting shown. One is retention of oil around the



BALL BEARING MOUNTING FOR VERTICAL PULLEY

bearing; the other is distribution of wear around both races.

A little consideration will show that if the races were mounted directly on the shaft, as would be the more obvious construction, the comparatively high speed of the pulley would tend to throw out the oil by centrifugal force at the outer race. If, however, the shaft rotates slowly or is stationary, the movement of the outer race will be small or nil with the arrangement shown. Another feature of this arrangement is that the top and bottom mountings on the shaft are interchangeable, and the whole arrangement can be inverted end for end or inclined to a considerable angle without impairing its oil holding ability.

Following the standard rule in mounting Hess-Bright bearings, the inner races are a light press fit on the hub supporting them, and are clamped solidly by the nuts and locking rings shown. It is most essential that creeping of the inner races be prevented, as the surfaces on which they are mounted are not large enough to resist peening if creeping begins. The outer races are a close fit in the mountings attached to the shaft. The upper one has a slight endwise clearance; the lower one comes against the supporting shoulder. This arrangement allows both outer races to creep slowly around, thereby distributing the wear of the ball paths. This is found to be an important aid to durability sometimes. The grooved and lipped closures shown at top and bottom should have the minimum clearance possible, in order to prevent dirt from entering. It is found that the creep of oil is sufficient to provide, in conjunction with the dust naturally settling, an effective seal against the actual entry of dust.

The drawing shows a standard form of hub on which interchangeable pulleys can be mounted of like width but different diameters to suit different requirements.

SAFETY DEVICE FOR STAMPING PRESSES

THE Benjamin safety device for stamping presses is intended to protect the hands of the operator of stamping presses, by necessitating the removal of both hands from the point of danger, to trip the press before the ram starts in its downward direction. The release of either hand permits the trip

STAMPING PRESS EQUIPPED WITH BENJAMIN SAFETY DEVICE

to return to its normal position, thus making it impossible for the press to repeat unless both hands are kept on the levers until the repeat operation is begun, in which event the operator would not have time to get his hands back into danger before the operation is completed.

The device consists of an operating lever normally inoperative, although free to move downward. This lever is made operative by the action of an electric retaining magnet through a circuit closer located on the opposite side of the press. Consequently the press cannot be tripped by the operating lever unless the circuit through the magnet is first closed and retained closed until after the press has been tripped.

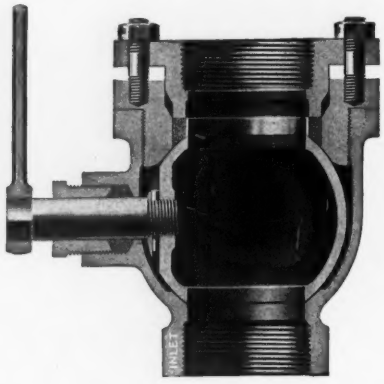
In addition to the protective feature, the use of the device results in an increased output of work where it is necessary to bring the hand into a position of danger for handling individual pieces. The operator knows the press cannot trip until both hands are removed. The increased confidence thus created materially increases the number of operations actually performed, with a corresponding increase in the amount of work done.

This safety device can easily be adapted to all the standard presses. No drilling of holes is necessary. The magnets are wound for 110 volt direct current, but can be used on 220 volt direct circuits by use of suitable resistance in series, or be equipped for a. c. circuits.

The manufacturer of this device is the Benjamin Electric Mfg. Co., 120-128 S. Sangamon St., Chicago.

HOWARD BALL VALVE

THIS valve, which is particularly designed for a blowoff, but is suitable for water, air, oil, gas, and so forth, is of the quick opening and closing type, actuated by a lever handle on the outside. The moving part consists of a hollow sphere the openings through which give the full area of the pipe. Tightness is assured by the use of a packing which is easily and quickly renewed and which gives a wiping contact with the surface of the ball. The



HOWARD QUICK ACTING BLOWOFF VALVE

valve opens and closes with a quarter turn, is adjustable to take up wear, and is designed to withstand strain due to water hammer. It is made of special bronze and is guaranteed for a working pressure of 300 lb. It is so arranged that the greater the pressure the tighter the valve seats. It has been found to remain tight after a sand test in which coarse sand is blown through it under boiler pressure and the valve operated several hundred times; this test seems to prove that sediment cannot affect the ball and that there will be no occasion for regrinding valve or seat. The Howard ball valve is made in sizes from ¾ in. to 3 in. by the Howard Iron Works of Buffalo, N. Y.

AN OPEN LETTER

To Boiler, Tank and Stack Manufacturers of the United States and Canada

AS legislation is about to be enacted in several of the United States, and a number of provinces in Canada, it behooves boiler, tank and stack manufacturers, as well as the manufacturers of material used in the construction of these several lines, to take cognizance of the coming convention of the American Boiler Manufacturers Association in New Orleans, La., Mar. 12 to 15 inclusive, at which time an effort will be made by the A. B. M. A. to take up and decide upon uniform specifications.

This organization has always stood for practical laws to protect the public, as well as the honest and conscientious boiler manufacturers. Its first action in 1889 was to establish the specifications for boiler steel and other material and construction which have become the standard by the general concurrence of manufacturers and engineers.

In 1907 Massachusetts adopted a code of Boiler Rules in general consonance with these specifications. This code has been adopted by several states since, and is likely to be very generally enacted throughout the country. It is important that any imperfections or crudities in these rules should be frankly criticised by practical boiler manufacturers, with a view to perfecting the code and eliminating the effects of unjust or ill-considered legislation.

Any individual or firm in one state would be at a disadvantage in combating an unfair bill, but deliberate and carefully considered endorsement of fair rules, or equally emphatic condemnation of unfair or extreme requirements by a body such as the A. B. M. A., with its prestige of a quarter of a century working in these lines, must and will have great weight with intelligent legislators everywhere.

The principles of conservation and regulation are among the most vital interests now under discussion by the American people, and it devolves upon you as practical and honest boiler manufacturers, and all manufacturers and supply houses, supplying boiler material, to see that this tremendous vital force is properly guided by correct information such as you can supply.

We cannot urge too strongly your attendance at the coming convention in New Orleans, Mar. 12 to 15 inclusive, and request you to send your name to the undersigned secretary of the Supplymen's Association, so that accommodations and arrangement for your entertainment can be made while in New Orleans.

(Signed) F. B. Slocum,
Secretary, Supplymen's Association of the American Boiler Manufacturers Association.

The above letter is sent out under my instructions and direction, and should receive thorough publicity throughout the United States and Canada before the coming convention.

(Signed) E. D. Meier,
President, American Boiler Manufacturers Association.

AT THE POWER PLANT now being erected in Lexington, by the Kentucky Traction and Terminal Company, at a cost of a half-million dollars, will be the tallest smokestack in Kentucky, if not in the entire South. The stack, or tower, will be constructed of reinforced concrete, and will be 225 ft. high. Approximately 4,000 barrels of Portland cement will be required to build the powerhouse tower, and the estimated cost is $10,000.

UNITED STATES OVERFEED STOKER

Adjustable feed, water cooling of parts exposed to the fire, and shielded dumping grate

AFTER fifteen years of building and selling underfeed stokers, the American Stoker Co., of 11 Broadway, New York City, has expanded its activities and placed upon the market an overfeed machine.

The construction consists of the ordinary hopper into which the fuel is delivered. Reciprocating in the bottom of this hopper are pushers, which shove the coal into the furnace upon the top grates, the travel of these pushers being adjusted by the attendant in accordance with the demands of the furnace. It will be noted that the back plate of the hopper which is exposed to the furnace fire, is water cooled, which prevents destruction by the furnace fire, and keeps this plate comparatively cool, so that there is no trouble experienced with the coal fusing in the hopper and adhering to it, thus preventing the proper feed of the fuel.

Another feature of importance in the hopper construction is the employment of a short pusher at each

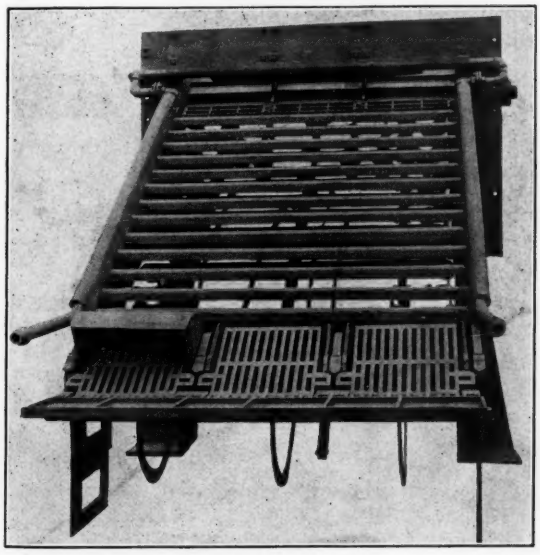


FIG. 1. REAR VIEW OF UNITED STATES OVERFEED STOKER

side, which provides means for feeding the sides as heavy as desired, irrespective of the amount of coal fed to other parts, in order to avoid air holes forming along the furnace walls.

The entire grate surface (except the ash dump) is composed of a series of horizontal shelves arranged as steps extending entirely across the furnace and forming an incline of about 35 deg. The grates are formed of 2 series, alike in design, but arranged alternately fixed and moving. The fixed grates are securely bolted to the side risers adjacent to the furnace walls and additional stationary risers extending through the center portion of the stoker. The moving grates are interleaved between the fixed grates, being supported and securely bolted to moving risers, which risers are supported at the lower end by rollers and at the upper end by arms attached to eccentrics upon the stoker shaft, the number of revolutions of this shaft being under the control of the attendant. The eccentrics give a constant length of travel, so that the extent of motion is unchanged, but the motion of the grates may be modified to suit the requirements of different kinds and grades of fuel. Thus for a coal subject to extreme coking, the grates may be adjusted to travel in the path of an eclipse, as shown in Fig. 2, or in a moment's time, may be changed so that the forward motion may be a straight line, while in retreat the grates may rise more or less than in the arc of an eclipse, carrying the grates at all times clear of loose coal, which may lie upon the rear of the grate below. The motion of the grates is such that the coal travels measurably even and at a uniform thickness from the

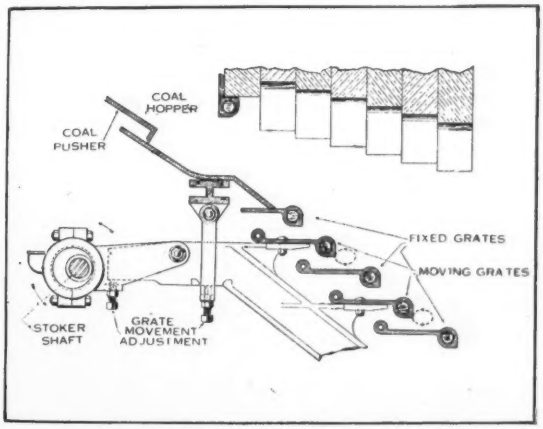


FIG. 2. SECTION OF GRATES AND ARCH

top or front of the furnace to the rear. Each grate assumes the roles of a positive pusher in its relation to the next, only to the coal and burning fuel, but to the ash and clinker as well, so that the latter are in due time thrown upon the ash dump at the rear and

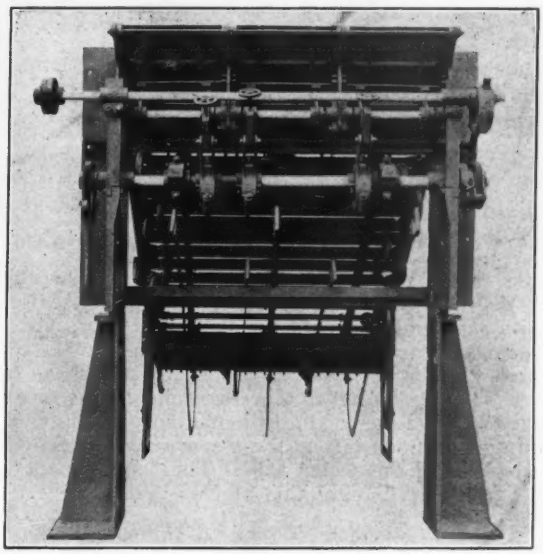


FIG. 3. FRONT VIEW OF U. S. OVERFEED STOKER

bottom. On account of the overlapping of the grates it is impossible for any fuel, no matter how fine, to sift through the grates into the ash pit.

Ash and clinker are separated from the good fuel by the attendant without effort other than the simple operation of the parts. Another important point is

that neither during the process of dumping, or after, is any cold air admitted to the furnace, as the space occupied by the dump grate is at all times covered with burning fuel.

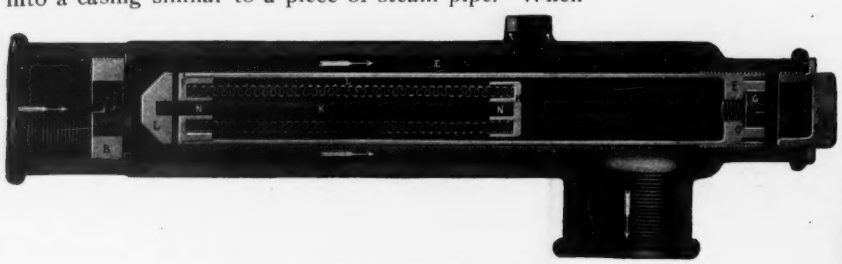
Partly imbedded in the bridge wall is a cylinder termed a "water back." This is constructed of standard steel boiler plate and connected direct with the water circulation of the boiler, and is provided with standard size boiler manhole and blowoff pipe for cleaning.

Each grate bar is protected from burning by a continual stream of water passing through that portion which is in direct contact with the burning fuel. Before casting, a pipe, properly shaped, is laid in the mold of the grate and the iron poured around it. The pipes used for this purpose are extra heavy cold drawn seamless tubing, made especially for the purpose, and tested under a pressure of 1000 lb. Connections from one grate to another are made by U shaped pipes with unions of special construction, with ground ball bronze seats, which are also tested with 1000 lb. air pressure under water.

Treating the moving grates as one unit and the stationary grates as another, water connection is made direct with the boiler to the bottom grate of each series, thence ascending from grate to grate until the top is reached, where another connection leads to the steam space of the boiler. There is no moving joint in connection with the whole installation.

THE SARCO STEAM TRAP

THIS is a patented apparatus having a valve with conical top which fits into a seat and derives its motion from the expansion of a fluid very sensitive to fluctuations in temperature and contained in a hermetically sealed tube. The whole thing fits into a casing similar to a piece of steam pipe. When



CROSS SECTION OF SARCO STEAM TRAP

steam strikes the outside of the sealed tube this fluid vaporizes, forcing the valve forward until it closes on its seat and prevents the egress of more steam. When the steam trap fills with water the fluid is condensed, the spring tube lengthens out and opens the valve. The fluid used as a pressure medium is so sensitive that it responds almost instantaneously by evaporating or condensing as the steam or water touches the outside of the sealed tube. The trap is made by the Sarco Fuel Saving Co., of New York.

THE LOUISVILLE, KY., office of the H. W. Johns-Manville Co. has been removed from the Lincoln Savings Bank Building to 205 Paul Jones Building in order to get larger quarters to take care of increasing business. The office will be in charge of J. R. Chowning, who has represented the company in the Louisville section for some time, traveling from the Milwaukee office. The entire line of Johns-Manville products will be handled by Mr. Chowning.

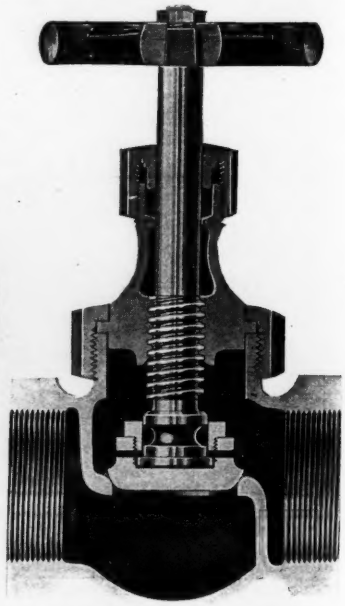
THE N. T. C. REGRINDING VALVE

AS the name indicates, one of the most prominent features of construction of this valve is the regrinding provision. For this purpose, the union bonnet ring is disconnected and the trimmings taken out, leaving the body of the valve in the line. A small amount of oil and emery dust is placed on the seat, the trimmings replaced in the body, the ring tightened one or 2 turns and a new seat is easily and quickly ground. As the bonnet is not gripped by the ring, it turns with the stem, which does not tend to rise.

For valves ½ in. or smaller, the disc is cast solid with the stem; for larger sizes, in which stem and disc are separate, a hole is provided through which a nail is slipped in order that the disc may turn with the stem when regrinding.

As shown here, both seat and disc are convex giving little chance for foreign matter to get between them at the point of contact, and the seat being of softer metal than the disc helps to make an accurate seat.

The short, compact bonnet, with male part fitting snugly into the valve and outer bonnet ring holding it securely give symmetrical appearance and rigidity, and avoid the use of gasket or compound. There is sufficient room, however, for full lift, and a 45-deg. beveled shoulder on the stem which makes a joint with



SECTION OF N. T. C. REGRINDING VALVE

the bonnet to permit packing the stem while under pressure. The box is fitted with a gland which forces the packing in without twisting it around.

N. T. C. valves are tested twice, once with cold water above the seat and once with it below the seat at 400 lb. pressure. A special test on ¼-in. valves at 125 lb. air pressure showed 327,094 times opening and closing before there was any leakage; after that the valve was reground, put back into service, and is working yet.

These valves made by the National Tube Co., of Pittsburgh, Pa., have special wheels with waved outline to give a good grip even if the hands are wet.

NEWS NOTES

THE COLUMBIA INCANDESCENT LAMP CO. has recently received from the Navy Department of the United States Government 2 orders, each calling for 25,000 clear and 5000 frosted 25-watt, 125-volt Columbia drawn-wire Mazda lamps. In connection with the use of drawn-wire Mazda lamps on battleships, tests have shown that these lamps are suitable for any kind of service conditions on board ships. As a particular case, after a target practice with 12-in. guns on the U. S. S. Delaware it was found that ⅓ to ½ the carbon lamps on board the vessel were put out of commission, while of the 12 drawn-wire Mazda lamps which were placed in the compartments immediately beneath the large guns where vibration was greatest, none were noticeably effected.

REINFORCED CONCRETE piles form an important part in the construction of foundations for the new reservoir of the H. J. Heinz Co., North Side, Pittsburgh. These piles, from 25 to 30 ft. long, are made in the field and driven by means of a 12,000-lb. drop hammer. The piles used for this work are of the plain, tapering type. The diameter of the head is 15 in. and the point 9 in., requiring 25.3 yd. of concrete of a total weight of 3770 lb.

The piles are reinforced with 8 ⅝-in. longitudinal wires and a No. 5 gage wire which passes around the pile at a 3-in. pitch throughout the entire length. It is further reinforced by 4 steel rings which are bound to the longitudinal wires and hold them in place. The point is protected by a shoe of No. 12 gage sheet steel 9 in. in diameter at the top and 1½ in. at the bottom, 12 in. long. To allow the pile to resist satisfactorily a heavy blow when being driven, the top is provided with a cushion produced by a spiral reinforcement at the top of the pile composed by 5¼ by 1 in. steel strips, 2 in. center to center, and 2⅛ by ⅜ in. steel rods 3 1/16 in. center to center. These piles are ready for driving in from 12 to 21 days after being poured. They are driven in clusters of 9 piles spaced on 3-ft. centers.

EXPERIMENTS ARE BEING carried out at the Rhode Island Co.'s power plant, Manchester St. Station, Providence, with oil fuel in connection with the installation of the 15,000-kw. Curtis 4-stage turbine, 11,000 volts at 700 r.p.m. Hannan's patent burners are being used and oil is fed to the burners at 50 lb. pressure, this pressure being produced by an electrically driven pump; steam at 145 lb. pressure is used for atomizing the oil in the burners. The experiments have been on for about 6 weeks and will be carried on for some time yet, but have not been as economical as at first expected. R. H.

GEORGE M. NEWHALL ENGINEERING COMPANY announces that after February 1, 1912, its general offices will be located at 807-8-9 Morris Building, 1421 Chestnut St., Philadelphia, Pa.

IN AN ADDRESS by Mr. Campbell of the National Electric Lamp Association, before the Nela Engineering Society, he stated that he has made extensive investigations of conditions under which lamps are operating on the circuits of some of the smaller central stations in Ohio, Nebraska and Iowa, and found in the larger percentage of central stations visited that the switchboard voltmeter was in error, the inaccuracy ranging from 1 to 10 volts with an average of about 4 volts. Mr. Campbell expects to continue his investigations with a view to obtaining additional information regarding the efficiency at which lamps are actually operated.

COMPLETION OF THE 3 new buildings of the Gould's Manufacturing Co., Seneca Falls, N. Y., was celebrated Friday evening, Jan. 19, by a grand ball, given by The Goulds Mutual Benefit Association. The 2 new machine shops, used for the ball were handsomely decorated and equipped with special illumination for the occasion, one being used for dancing and the other fitted up for the dining hall and cloak room; also with card tables for those who did not care to dance. From 8 until 10 p. m. a concert was given by Conway's Band of Syracuse, N. Y., after which the floor was cleared for dancing. The new hard maple floor had an excellent surface and there was plenty of room for all, although over 2000 were present. Everyone reported a most enjoyable time and the association, which is an organization for the benefit of sick members, made a handsome profit from the proceeds.

MCLEOD & HENRY CO., of Troy, N. Y., the manufacturers of the Steel Mixture boiler setting specialties, have opened an office in Boston to take care of their trade in that vicinity. A. W. Pettie, who has been representing the firm in the middle west, will have charge. As the Steel Mixture products are very generally used throughout the textile mills of New England it is expected that the new office will prove a great convenience. The address is Room 954 Oliver Building, 141 Milk St.

THE EAGEN-ROGERS STEEL & IRON CO. has just been incorporated under the laws of the State of Pennsylvania, with a capitalization of $100,000. It has acquired a 5-acre tract on the Pennsylvania Railroad in the Chester district between Crum Lynne and Eddystone, Pa., and is now erecting modern steel buildings, the contract for which has been let to the McClintic-Marshall Construction Co. A specialty will be made of light steel castings up to 200 lb. in weight, in addition to grey iron castings and the manufacture of specialties. It is of special interest that this company will furnish steel made by the electric process, having obtained American rights for the most successful process now in use in England. Those most actively interested in the company are Daniel C. Eagan and John I. Rogers. Mr. Eagan is a son of the late Daniel Eagan and has had wide experience in this line of work. Mr. Rogers is an engineer and was formerly with the Midvale Steel Company in charge of various departments and has been in consulting practice for the last few years in New York and Philadelphia. The company's plant will be in active operation by March 1st. when it will be in a position to take care of its customers.

ON SATURDAY, JANUARY 20, 1912, the Marshall Drug Store building fronting on the west side of the Public Square of Cleveland, was swept by fire which left only the shell of the building.

For a number of years the largest and most prominet electric signs in the city have been located on this building. At present the largest of these is the Goodrich Tire sign which was erected and is operated by the A. & W. Electric Sign Company of Cleveland. This sign, the letters of which are 6 ft. high, contains in the neighborhood of 900 Mazda lamps of the 2½-watt, 11½-volt sign type.

As the weather at the time of the fire was very cold, the large quantity of water which was used to quench the flames, froze quickly, causing the building to be coated with ice. The large signs received their share of the water from the fire hose and were also heavily coated with ice. When the current was turned on at night the signs were found to be none the worse for the conflagration; there being only one lamp destroyed. This speaks well for the wiring construction as well as for the ruggedness of the lamps.

CATALOG NOTES

TO THOSE INTERESTED IN BOATS and their construction the chart of a modern submarine boat with parts numbered and named, recently published by the Norman W. Henley Publishing Co., of New York, will be found of great interest. It comes printed on heavy coated paper, clear and distinct, and is mailed, postage paid, for 25 cents.

WITH THE JANUARY issue, The Electric Journal is mailing its Eight Year Topical Index. This Index, which has become a noteworthy feature in connection with this publication, now covers some 6800 pages of valuable technical material representing a wide range of articles of engineering interest. These articles, as bound in permanent form in 8 volumes, are made readily accessible by the use of the topical method of indexing, as it is necessary only to refer to the index in the latest volume to find references to all articles which have appeared on any desired subject. In general, the article references are classified under four divisions: Generation, Transformation, Transmission and Utilization, these subjects representing a logical arrangement. A key is given on the first page of the index to indicate the location of each of the various sub-divisions.

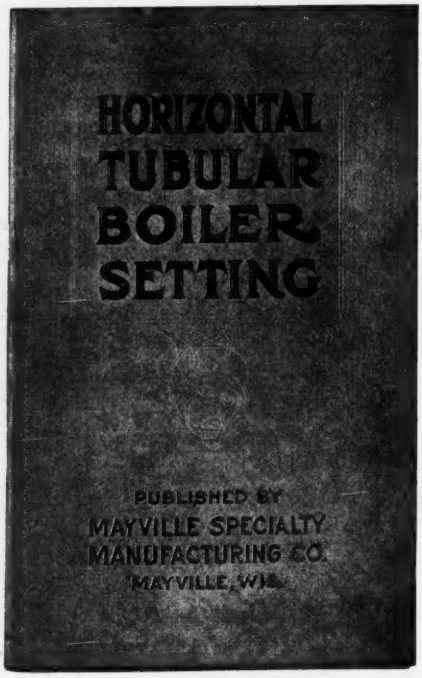
The index may be used in bound form, or the individual items may be mounted on cards and the index used as the basis of a card file or it may be fitted in with a system already in use.

WITH INCREASE OF POPULATION and, through a considerable part of the county decrease in the fertility of the soil, the problem of increasing crops, either by better cultivation or by the use of better seed, becomes one of national importance. Seed which will increase either the amount of the yield or the quality of the crop is, therefore, an important means of increasing national wealth and decreasing the household expenses of every family. A pamphlet on "Obtaining a Larger Yield of Better Grain," which contains a paper read before the Council of North American Grain Exchanges, treats this subject carefully and at length. To everyone directly interested in the production of grain this pamphlet is of vital interest and it seems, therefore, worthy the attention of those who may have friends interested in the matter, even though they are not personally interested, so that they may pass the word along. Copies of the pamphlet may be obtained from Bert Ball, secretary of the Seed Committee, North American Grain Exchanges, Merchants Exchange, St. Louis.

GALLAGHER & CO., of New York, are placing on the market a system of furnace construction called Acme Oxygen Arch Plates, Door Jambs and Grates. The principle of this system is to use hollow and perforated jamb blocks and other parts so that currents of hot air will be supplied under and above the grates for combustion. These combined with a sectional shaking grate make up a system which is fully described in their catalog just issued.

HENRY R. WORTHINGTON, 115 Broadway, New York City has just issued bulletin W-188, giving an extended description of the Worthington horizontal, triple-expansion, high-duty pumping engine installed in the Hope Station of the Providence, R. I., Water Works. This engine has a capacity of 10,000,000 gallons per 24 hours against a head of 85 lb. per square inch and its design represents the latest practice in pumping engines of this type. One of its especially interesting features is its high-duty attachment involving the use of compensating cylinders taking the place of a flywheel. The arrangement is preferable to a flywheel in that the power exerted increases in almost exact ratio with the decrease of the power of the expanding steam. The account given of the duty trials shows that the guaranteed duty was exceeded at full load by 4.5 per cent and at reduced capacity by 12.5 per cent. The actual duty at full load was 149,500,000 foot-pounds per 1000 lb. of dry steam. The bulletin also shows and describes a similar engine installed at Fall River, Mass. The bulletin will be especially interesting to municipalities facing the problem of securing adequate service economically.

HORIZONTAL TUBULAR BOILER SETTING is a subject on which every engineer sooner or later needs information. In a convenient and attractive book the Mayville Specialty Mfg. Co., of Mayville, Wis., has brought together a fund of information



which is well worth while possessing and studying. It covers the subject of boiler foundations, foundation material, dimensions of foundations and amount of material needed, dimensions and arrangement of the setting, setting up the boiler, building the walls, bridge wall, combustion chamber, arrangement of the blow-off, directions for laying different kinds of brick, provision for expansion, supporting the boiler, the top covering, starting a new boiler, laying up a boiler, and the construction of back arches and fire door arches. Incidentally it shows the method of construction and the advantages of use of the Monarch arches for fire door and combustion chamber. The cut shows the attractiveness of the book and it is as useful as it is attractive.

FROM THE INGERSOLL-RAND CO. is received a folder on the subject of Air Lift Pumping, showing the arrangement of a typical plant and how the system is being used for various purposes. It is accompanied by a mailing card permitting of a convenient method of requesting information on the subject, which can be had by writing to the company at 11 Broadway, New York.

THE GENERAL ELECTRIC CO. has just issued an attractive publication devoted to a detailed description of its double truck type of gas-electric car. The publication is elaborately illustrated, and contains considerable data relative to the subject. It includes plans and elevations of cars of various sizes. The number of the Bulletin is 4855. In Bulletin 4863 is described G. E. Gem lamp. This lamp is intended to replace the carbon lamp as a free renewal lamp. The bulletin compares the carbon with the Gem lamp and shows the advantages derived by the use of the latter.

Bulletin No. 4772, entitled "Electric Automobile Appliances," supersedes a previous bulletin on this subject, and should be of interest to all owners or users of electric automobiles for either pleasure or business. The bulletin illustrates and describes an outfit for charging the storage batteries, as well as a combination ammeter and voltmeter for automobiles. It illustrates Mazda lamps for head-light, side-light and tail-light, and also a lamp for limousine illumination. Automobile motors, controllers, and air compressor outfits are illustrated and described.

A bulletin entitled "Engine Type Continuous Current Generators, Forms RB and RBO for Lighting and Power," illustrates and describes direct current generators for 2 and 3-wire systems, from 25 to 250 kw., and for standard voltages.

Bulletin No. 4775, entitled "Type KS Single-Phase Induction Motors," describes a motor offered by the company to meet the power requirements of establishments which, for some reason, are unable to secure other than single-phase current. This motor is, in general, adapted to drive geared and belted machinery requiring constant speed with light or moderate starting torque. It is made in capacities of from 1 to 15, hp. and wound for 110 or 220 volts, 60 cycles.

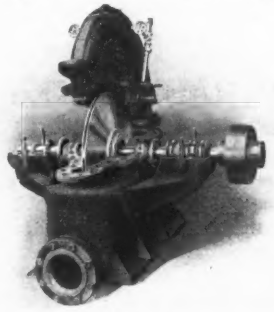
Bulletin No. 4766 illustrates and describes the GE Tantalum Incandescent Lamp for general illumination for 100 to 125, and 200 and 250 volts, compares the cost and efficiency of these lamps with those of the carbon and Gem lamps, and contains considerable data of use to those interested in the subject.

WIRE ROPE is the title of a valuable book issued by the Trenton Iron Co., of Trenton, N. J., containing a full list of the different kinds of rope manufactured, the fittings used in making fast wire rope, and full directions for the computation of rope transmissions with explanation of the apparatus used, the size of wheels allowable for different sizes of rope, methods of splicing wire rope, and other information which has been worked out and gathered by the engineer of the company, William Hewitt, in the course of a long experience. It is a substantial book, beautifully printed and well bound, and is well worth possessing.

AS SHOWING THE USES of separators in a power plant, Engineering Leaflet No. 10, issued by the Harrison Safety Boiler Works, is helpful. It discusses the use of separators for guarding against foaming and priming in boilers, their use for protecting engines against water, their use for the protection of superheaters, how vibration of steam pipes may be relieved by using receiver separators, the use of such separators to reduce radiation from steam lines, separators for improving lubrication of reciprocating engines, separators for removing oil from steam, the use of separators in connection with exhaust-steam turbines, the design of separators for removing oil from steam before condensation, and other topics of similar nature. It is a book of 48 pages, well illustrated and carefully compiled, and is a text-book on the subjects which it treats.

COOKSON CAST IRON HEATERS and receivers with cut-out valves are described in a new 24-page catalog just issued by the Bates Machine Co., Joliet, Ill. This heater serves as a purifier, filter, oil separator, and condensation receiver and possesses the special feature of being able to purify all the exhaust steam from the engine and auxiliaries. The new type of oil separator used on this heater is provided with cutout valves that permit cleaning of the heater body without interference with the functions of the oil separator. This catalog is sent free on application.

BULLETIN 105, issued by the Goulds Mfg. Co., of Seneca Falls, N. Y., describes its single-stage, single-suction centrifugal pumps. It tells of the purposes to which they are adapted, the mechanical construction, points out the different parts, such as casings, impeller, shaft and bearings, and shows how the pumps are con-



structed and put together. An interesting and valuable feature is the table of sizes, capacities and dimensions, also the speeds and horsepowers required at different speeds when pumping against various heads from 10 to 100 feet. Different methods of drive are shown and useful suggestions given about installing pumps.

A CATALOG DESCRIBING the method of cleaning a boiler with the Vulcan Soot Cleaner, made by the Vulvan Soot Cleaner Co., comes from G. L. Simonds & Co., of 64 E. Van Buren St., Chicago. The Vulcan Company factory is located at Du Bois, Pa., but the catalog is from the western sales agents, as stated above.

BOILER CLEANING LOGIC, as applied to the external surfaces of steam boilers, is the title of an attractive booklet, issued by the Bayer Steam Soot Blower Co., of St. Louis, Mo. It describes the Bayer apparatus and system, and shows its application to the Heine water-tube boiler, and explains the advantages to be derived from its use.

DEPARTMENT OF THE INTERIOR, Bureau of Mines, has just issued the following new publications: Bulletin 15. Investigations of explosives used in coal mines, by Clarence Hall, W. O. Snelling, and S. P. Howell, with an introduction by C. E. Munroe, and a chapter on the natural gas used at Pittsburgh, by G. A. Burrell. 1911. 197 pp. Technical Paper 6. The rate of burning of fuse as influenced by temperature and pressure, by W. O. Snelling and W. C. Cope. 1911. 28 pp. Technical Paper 7. Investigations of fuse and miners' squibs, by Clarence Hall and S. P. Howell. 1911. 19 pp. Reprints: Bulletin 31. Incidental problems in gas-producer tests, by R. H. Fernald, C. D. Smith, J. K. Clement, and H. A. Grine, 29 pp. Reprint of United States Geological Survey Bulletin 392. Copies will not be sent to persons who received Bulletin 392. Bulletin 32. Commercial deductions from comparisons of gasoline and alcohol tests on internal-combustion engines, by R. M. Strong. 38 pp. Reprint of United States

Geological Survey Bulletin 392. Copies will not be sent to persons who received Bulletin 392. Bulletin 33. Comparative tests of run-of-mine and briquetted coal on the torpedo boat Biddle, by W. T. Ray and Henry Kreisinger. 49 pp. Reprint of United States Geological Survey Bulletin 412. Copies will not be sent to persons who received Bulletin 412.

The Bureau of Mines has copies of these publications for free distribution, but can not give more than one copy of the same bulletin to one person. Requests for all papers can not be granted without satisfactory reason. In asking for publications please order them by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D. C.

ACTON AUTOMATIC STEAM, WATER, Air and Vacuum Specialties, as made by John Acton of Brooklyn, N. Y., are described in a pamphlet catalog just received.

TRADE NOTES

IN THIS TIME of rise of prices on nearly all manufactured products, the announcement of the C. W. Hunt Co., of West New Brighton, N. Y., that owing to important economies resulting from standardization of design and improved methods of manufacture, the company announces a reduction in selling prices, is an unusual and welcome novelty. This applies to the entire line of conveyors, hoisting machinery, cable and industrial railways, electric locomotives, and apparatus which goes with such systems.

THE SAFETY VALVE is the watch dog of boiler safety, but the letter below, received by the Consolidated Safety Valve Co. seems to indicate a mysterious transformation, or an active spirit of fun on the part of somebody who "rearranged" the safety-valve guarantee tag and made it part of the canine wardrobe:

Gentlemen: Your dog lives at this address:
Arlington, New York,
Italian Schanty. Crosstown, Poughkeepsie, N. Y.

I have found a dark red haired dog with collar and tag having the following address: The Consolidated Safety Valve Co., Bridgeport and New York, Valve No. 670 pops at 80 closes at 75.

Therefore, if you wish your dog, reply stating what we must do in order to deliver same to you.

Yours, etc.,
(Signed) Joe Vessella.

SINCE LAST NOVEMBER, 1911, the York Manufacturing Co. has sold a total of 18 ice-making plants, aggregating a total of 653 tons of ice daily, and a total of 58 refrigerating plants, aggregating a total of 1219 tons of refrigeration daily. In addition to the above, this company has sold a large quantity of direct expansion piping; ammonia condensers of the double pipe and atmospheric types; freezing and distilling systems, supplies and fittings.

RAPIDLY INCREASING DEMAND in Pittsburgh and vicinity for asbestos, magnesia and other products of the H. W. Johns-Manville Co., has necessitated a move from its present location in Liberty Avenue, above Ninth Street, to larger quarters. The Pittsburgh Branch of the H. W. Johns-Manville Co., now occupies the entire 8-story stone, reinforced concrete and steel building at the northeast corner of Wood Street and First Avenue, which has been leased by them for a term of years.

PRACTICAL ENGINEER CLASSIFIED ADVERTISEMENTS

Advertisements in this section are inserted under regular headings at the rates of 30 cents per line. About nine words make a line. No display type allowed, but the first three words may be set in capital letters. Minimum space sold, two lines.

Under classification, "Positions Wanted," advertisements not exceeding four lines will be inserted for subscribers once free of charge.

To insure proper classification, copy must reach this office 10 days preceding publication.

Positions Wanted

POSITION WANTED—By a steam and electrical engineer and a good wireman with ten years' experience. Married and sober. Oakley V. Ray, 616 W. Locust St., Waverly, Iowa. 2-15-1

POSITION WANTED—As Engineer in small or assistant in large plant. Six years' practical experience with water tube and return tubular boilers, high speed and Corliss engines, A. C. and D. C. generators and motors. Address E. Thies, Hastings, Mich. 2-15-1

POSITION WANTED—By first-class engineer and millwright; 12 years' experience as engineer and on all kinds of repairs, wiring, etc. Best references. Will go any place where night work is not a necessity. Address Box 202, Practical Engineer, Chicago, Ill. 2-15-1

POSITION WANTED—As engineer in small plant. Have had experience with direct current generators. No bad habits. Good references. 30 years old. Position in Illinois preferred. Address Box 203, Practical Engineer, Chicago, Ill. 2-15-1

POSITION WANTED—By engineer with 6 years' experience with locomotive crane and also as a clam shell engineer. Can give best references. Bert Moulton, General Delivery, Michigan City, Ind. 2-15-1

Wanted

IF YOU ARE a night engineer, spend a few hours each day taking subscriptions for Practical Engineer. You will be paid well. Write the Subscription Dept. They will start you in at once. 2-15-2

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For Sale

FOR SALE—HAS NEVER BEEN unpacked. One new Hawthorne alternating current generator, 50 K. W. 3 Phase, 60 cycles, 2300 volts, direct connected to new Chuse automatic engine, Complete with new exciter switchboard and instruments. Address Missouri Training School for Boys, Boonville, Missouri. 2-15-1

Miscellaneous

FOR EXCHANGE—25 BOOKS ON steam and electrical engineering (Hawkins I. C. S., etc.) for 6 or 8 light dynamo or offer. B. W. Snyder, St. John, Kansas. 2-15-1

MAKE MONEY on the side. Here's your chance to pick out some money for yourself. Get subscriptions for Practical Engineer. It pays well. Just drop a line to the Subscription Dept. They will tell you how. 1-15-3

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write to-day. M. Y. C., 1413 W. Jackson Blvd., Chicago, Ill.